8840A

DIGITAL MULTIMETER

Instruction Manual

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DIGITAL MULTIMETER

Instruction Manual

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8840A Digital Multimeter

Section 1
Introduction and Specifications

1-1. INTRODUCTION

This manual provides complete operating instructions and service information for the 8840A. If you want to get started using your 8840A right away, proceed to the operating instructions in Section 2. If you intend to use the 8840A with the IEEE-488 Interface (Option -05), read Sections 2 and 3.

1-2. THE 8840A DIGITAL MULTIMETER

The Fluke 8840A Digital Multimeter is a high-performance 5-1/2 digit instrument designed for general-purpose bench or systems applications. Features of the 8840A include:

- Highly legible vacuum fluorescent display
- Intuitively easy front panel operation
- Basic dc accuracy of 0.005% for 1 year
- 2-wire and 4-wire resistance measurement
- DC current measurement
- Up to 100 readings per second
- Closed-case calibration (no internal adjustments)
- Built-in self-tests

1-3. OPTIONS AND ACCESSORIES

A number of options and accessories are available for the 8840A which can be easily installed at any time. The options include:

- IEEE-488 Interface (Option -05), featuring:

  Full programmability
  Simple and predictable command set
  Fast measurement throughput
  External Trigger input connector
  Sample Complete output connector
  Automated calibration
  Low cost

- True RMS AC (Option -09), featuring:

  AC voltage measurement
  AC current measurement

Accessories include a variety of rack mounting kits, probes, test leads, and cables. Full information about options and accessories can be found in Section 8.

1-4. SPECIFICATIONS

Specifications for the 8840A are given in Table 1-1. External dimensions are shown in Figure 1-1.

Table 1-1. Specifications

DC VOLTAGE

Input Characteristics

RANGE	FULL SCALE 5½ DIGITS	RESOLUTION		INPUT RESISTANCE
		5½ DIGITS	4½ DIGITS*	
200 mV	199.999 mV	1 μV	10 μV	≥10,000 MΩ
2V	1.99999V	10 μV	100 μV	≥10,000 MΩ
20V	19.9999V	100 μV	1 mV	≥10,000 MΩ
200V	199.999V	1 mV	10 mV	10 MΩ
1000V	1000.00V	10 mV	100 mV	10 MΩ

*4½ digits at the fastest reading rate.

Accuracy

NORMAL (S) READING RATE ..... ±(% of Reading + Number of Counts).

RANGE	24 HOUR 23±1°C[1]	90 DAY 23±5°C	1 YEAR 23±5°C
200 mV[2]	0.003 + 3	0.007 + 4	0.008 + 4
2V	0.002 + 2	0.004 + 3	0.005 + 3
20V	0.002 + 2	0.005 + 3	0.006 + 3
200V	0.002 + 2	0.005 + 3	0.006 + 3
1000V	0.003 + 2	0.005 + 3	0.007 + 3

[1] Relative to calibration standards.
[2] Using Offset control.

MEDIUM AND FAST RATES: ..... In medium rate, add 2 counts to number of counts. In fast rate, use 2 counts for the number of counts.

Operating Characteristics

TEMPERATURE COEFFICIENT ..... <±(0.0006% of Reading + 0.3 Count) per °C from 0°C to 18°C and 28°C to 50°C.
MAXIMUM INPUT ..... 1000V dc or peak ac on any range.
NOISE REJECTION ..... Automatically optimized at power-up for 50, 60, or 400 Hz.

RATE	READINGS/ SECOND[1]	FILTER	NMRR[2]	PEAK NM SIGNAL	CMRR[3]
S	2.5	Analog & Digital	>98 dB	20V or 2x FS[4]	>140 dB
M	20	Digital	>45 dB	1x FS	>100 dB
F	100	None	—	1x FS	>60 dB

[1] Reading rate with internal trigger and 60 Hz power line frequency. See "Reading Rates" for more detail.
[2] Normal Mode Rejection Ratio, at 50 or 60 Hz ±0.1%. The NMRR for 400 Hz ±0.1% is 85 dB in S rate and 35 dB in M rate.
[3] Common Mode Rejection Ratio at 50 or 60 Hz ±0.1%, with 1 kΩ in series with either lead. The CMRR is >140 dB at dc for all reading rates.
[4] 20 volts or 2 times Full Scale whichever is greater, not to exceed 1000V.

Table 1-1. Specifications (cont)

TRUE RMS AC VOLTAGE (OPTION -09)

Input Characteristics

RANGE	FULL SCALE 5½ DIGITS	RESOLUTION		INPUT IMPEDANCE
		5½ DIGITS	4½ DIGITS*	
200 mV	199.999 mV	1 μV	10 μV	1 MΩ shunted by <100 pF
2V	1.99999V	10 μV	100 μV	
20V	19.9999V	100 μV	1 mV	
200V	199.999V	1 mV	10 mV	
700V	700.00V	10 mV	100 mV	

*4½ digits at the fastest reading rate.

Accuracy

NORMAL (S) READING RATE ..... ±(% of Reading + Number of Counts). For sinewave inputs ≥10,000 counts[1].

FREQUENCY (Hz)	24 HOURS[2] 23±1°C	90 DAY 23±5°C	1 YEAR 23±5°C
20-45	1.2 + 100	1.2 + 100	1.2 + 100
45-100	0.3 + 100	0.35 + 100	0.4 + 100
100-20k	0.07 + 100	0.14 + 100	0.16 + 100
20k-50k	0.15 + 120	0.19 + 150	0.21 + 200
50k-100k	0.4 + 300	0.5 + 300	0.5 + 400

[1] For sinewave inputs between 1,000 and 10,000 counts, add to Number of Counts 100 counts for frequencies 20 Hz to 20 kHz, 200 counts for 20 kHz to 50 kHz, and 500 counts for 50 kHz to 100 kHz.
[2] Relative to calibration standards.

MEDIUM AND FAST READING RATES ... In medium rate, add 50 counts to number of counts. In fast rate the specifications apply for sinewave inputs ≥1000 counts and >100 Hz.

NONSINUSOIDAL INPUTS ..... For nonsinusoidal inputs ≥10,000 counts with frequency components ≤100 kHz, add the following % of reading to the accuracy specifications.

FUNDAMENTAL FREQUENCY	CREST FACTOR		
	1.0 TO 1.5	1.5 TO 2.0	2.0 TO 3.0
45 Hz to 20 kHz	0.05	0.15	0.3
20 Hz to 45 Hz and 20 kHz to 50 kHz	0.2	0.7	1.5

Operating Characteristics

MAXIMUM INPUT ..... 700V rms, 1000V peak or 2×10^7 Volts-Hertz product (whichever is less) for any range.

Table 1-1. Specifications (cont)

TEMPERATURE COEFFICIENT ..... ±(% of Reading + Number of Counts) per °C, 0°C to 18°C and 28°C to 50°C.

FOR INPUTS	FREQUENCY IN HERTZ		
	20-20k	20k-50k	50k-100k
⩾10,000 counts	0.019 + 9	0.021 + 9	0.027 + 10
⩾1,000 counts	0.019 + 12	0.021 + 15	0.027 + 21

COMMON MODE REJECTION ..... >60 dB at 50 or 60 Hz with 1 kΩ in either lead.

CURRENT

Input Characteristics

RANGE	FULL SCALE 5½ DIGITS	RESOLUTION	
		5½ DIGITS	4½ DIGITS*
2000 mA	1999.99 mA	10 μA	100 μA

*4½ digits at the fastest reading rate.

DC Accuracy

NORMAL (S) READING RATE ..... ±(% of Reading + Number of Counts).

	90 DAYS 23±5°C	1 YEAR 23±5°C
⩽1A	0.04 + 4	0.05 + 4
>1A	0.1 + 4	0.1 + 4

MEDIUM AND FAST READING RATES ... In medium reading rate, add 2 counts to number of counts. In fast reading rate, use 2 counts for number of counts.

AC Accuracy (Option -09)

NORMAL (S) READING RATE ..... ±(% of Reading + Number of Counts).
1 Year, 23±5°C, for sinewave inputs ⩾10,000 counts.

FREQUENCY IN HERTZ		
20-45	45-100	100-5k*
2.0 + 200	0.5 + 200	0.4 + 200

*Typically 20 kHz

Table 1-1. Specifications (cont)

MEDIUM AND FAST READING RATES ... In medium rate, add 50 counts to number of counts. In fast reading rate, for sinewave inputs ≥1000 counts and frequencies >100 Hz, the accuracy is ±(0.2% of reading + 30 counts).

NONSINUSOIDAL INPUTS ..... For nonsinusoidal inputs ≥10,000 counts with frequency components ≤100 kHz, add the following % of reading to the accuracy specifications.

FUNDAMENTAL FREQUENCY	CREST FACTOR		
	1.0 TO 1.5	1.5 TO 2.0	2.0 TO 3.0
45 Hz to 5 kHz	0.05	0.15	0.3
20 Hz to 45 Hz	0.2	0.7	1.5

Operating Characteristics

TEMPERATURE COEFFICIENT ..... Less than 0.1 x accuracy specification per °C from 0°C to 18°C and 28°C to 50°C.

MAXIMUM INPUT ..... 2A dc or rms ac. Protected with 2A, 250V fuse accessible at front panel, and internal 3A, 600V fuse.

BURDEN VOLTAGE ..... 1V dc or rms ac typical at full scale.

RESISTANCE

Input Characteristics

RANGE	FULL SCALE 5½ DIGITS	RESOLUTION		CURRENT THROUGH UNKNOWN
		5½ DIGITS	4½ DIGITS*	
200Ω	199.999Ω	1 mΩ	10 mΩ	1 mA
2 kΩ	1.99999 kΩ	10 mΩ	100 mΩ	1 mA
20 kΩ	19.9999 kΩ	100 mΩ	1Ω	100 μA
200 kΩ	199.999 kΩ	1Ω	10Ω	10 μA
2000 kΩ	1999.99 kΩ	10Ω	100Ω	5 μA
20 MΩ	19.9999 MΩ	100Ω	1 kΩ	0.5 μA

*4½ digits at the fastest reading rate.

Accuracy

NORMAL (S) READING RATE ..... ±(% of Reading + Number of Counts)[1]

RANGE	24 HOUR 23±1°C[2]	90 DAY 23±5°C	1 YEAR 23±5°C
200Ω	0.004 + 3	0.011 + 4	0.014 + 4
2 kΩ	0.0028 + 2	0.01 + 3	0.013 + 3
20 kΩ	0.0028 + 2	0.01 + 3	0.013 + 3
200 kΩ	0.0028 + 2	0.01 + 3	0.013 + 3
2000 kΩ	0.023 + 3	0.027 + 3	0.028 + 3
20 MΩ	0.023 + 3	0.043 + 4	0.044 + 4

[1] Using Offset control.

[2] Relative to calibration standards.

Table 1-1. Specifications (cont)

Accuracy, cont

MEDIUM AND FAST READING RATES ... In medium rate, add 2 counts to the number of counts for the 200Ω through 200 kΩ ranges and 3 counts for the 2000 kΩ and 20 MΩ ranges. In fast reading rate, use 3 counts for the number of counts for the 200Ω range, and 2 counts for all other ranges.

Operating Characteristics

TEMPERATURE COEFFICIENT ..... Less than 0.1 x accuracy specification per °C from 0°C to 18°C and 28°C to 50°C.
MEASUREMENT CONFIGURATION ..... 2-wire or 4-wire.
OPEN CIRCUIT VOLTAGE ..... Less than 6.5V on the 200Ω through 200 kΩ ranges. Less than 13V on the 2000 kΩ and 20 MΩ ranges.
INPUT PROTECTION ..... To 300V rms.

READING RATES

READING RATES
WITH INTERNAL TRIGGER ..... (readings per second).

RATE	POWER LINE FREQUENCY*		
	50 HZ	60 HZ	400 HZ
S	2.08	2.5	2.38
M	16.7	20	19.0
F	100	100	100

*Sensed automatically at power-up.

AUTOMATIC SETTLING TIME DELAY

Time in milliseconds from single trigger to start of A/D conversion, Autorange off.

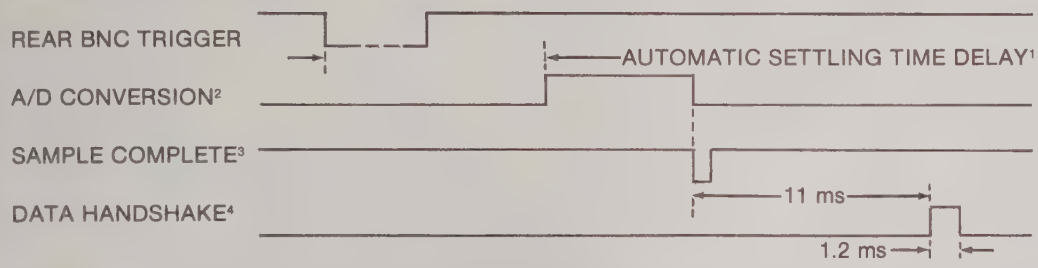
FUNCTION	RANGE	READING RATE			NUMBER OF COUNTS FROM FINAL VALUE[1]
		S	M	F	
VDC	200 mV	342	61	9	5
	2V-1000V	342	17	9	5
VAC	All	551	551	551	30 (Note 2)
mA DC	2000 mA	342	17	9	5
mA AC	2000 mA	551	551	551	30 (Note 2)
Ohms	200Ω	394	105	17	5
	2 kΩ	322	17	13	5
	20 kΩ	342	17	13	5
	200 kΩ	141	121	21	5
	2000 kΩ	141	101	81	10
	20 MΩ	1020	964	723	30

1. Difference between first reading and final value for an in-range step change coincident with trigger.
2. For slow reading rate. 50 counts for medium rate; 10 counts for fast rate.

Table 1-1. Specifications (cont)

EXTERNAL TRIGGER TIMING CHARACTERISTICS

The following diagram shows the nominal timing for the various processes which take place between an external trigger and data sent out on the IEEE-488 interface. Delays will vary if a second trigger comes before the data handshake is complete.



NOTES:

1. Time from single trigger to start of A/D conversion. (See "Automatic Settling Time Delay" on previous page.) If the delay is disabled by using the T3 or T4 command, then the delay is 1 ms ±150 μs. When the 8840A is triggered with an IEEE-488 command (GET or ?), the automatic settling time delay begins after the trigger command has been processed and recognized.

2. A/D conversion time is dependent on the reading rate and power-line frequency:

RATE	A/D CONVERSION TIME (ms)		
	50 Hz	60 Hz	400 Hz
S	472	395	414
M	52	45	47
F	7	7	7

3. Sample Complete is a 2.5 μs pulse which indicates that the analog input may be changed for the next reading.

4. When talking to a fast controller.

GENERAL

COMMON MODE VOLTAGE	1000V dc or peak ac, or 700V rms ac from any input to earth.
TEMPERATURE RANGE	0 to 50°C operating, -40 to 70°C storage.
HUMIDITY RANGE	80% RH from 0 to 35°C, 70% to 50°C.
WARMUP TIME	1 hour to rated specifications.
POWER	100, 120, 220, or 240V ac ±10% (250V ac maximum), switch selectable at rear panel. 50, 60, or 400 Hz, automatically sensed at power-up. 20 VA maximum.
VIBRATION	Meets requirements of MIL-T-28800C for Type III, Class 3, Style E equipment.
PROTECTION	ANSI C39.5 and IEC 348, Class I.
SIZE	8.9 cm high, 21.6 cm wide, 37.1 cm deep(3.47 in high, 8.5 in wide, 14.4 in deep).
WEIGHT	Net, 3.4 kg (7.5 lb); shipping, 5.0 kg (11 lb).
INCLUDED	Line cord, test leads, Instruction/Service Manual, IEEE-488 Quick Reference Guide, (Option -05 only), and instrument performance record.
IEEE-488 INTERFACE FUNCTION	Option allows complete control and data output capability, and supports the following interface function subsets: SH1, AH1, T5, L4, SR1, RL1, DC1, DT1, E1, PP0, and C0.

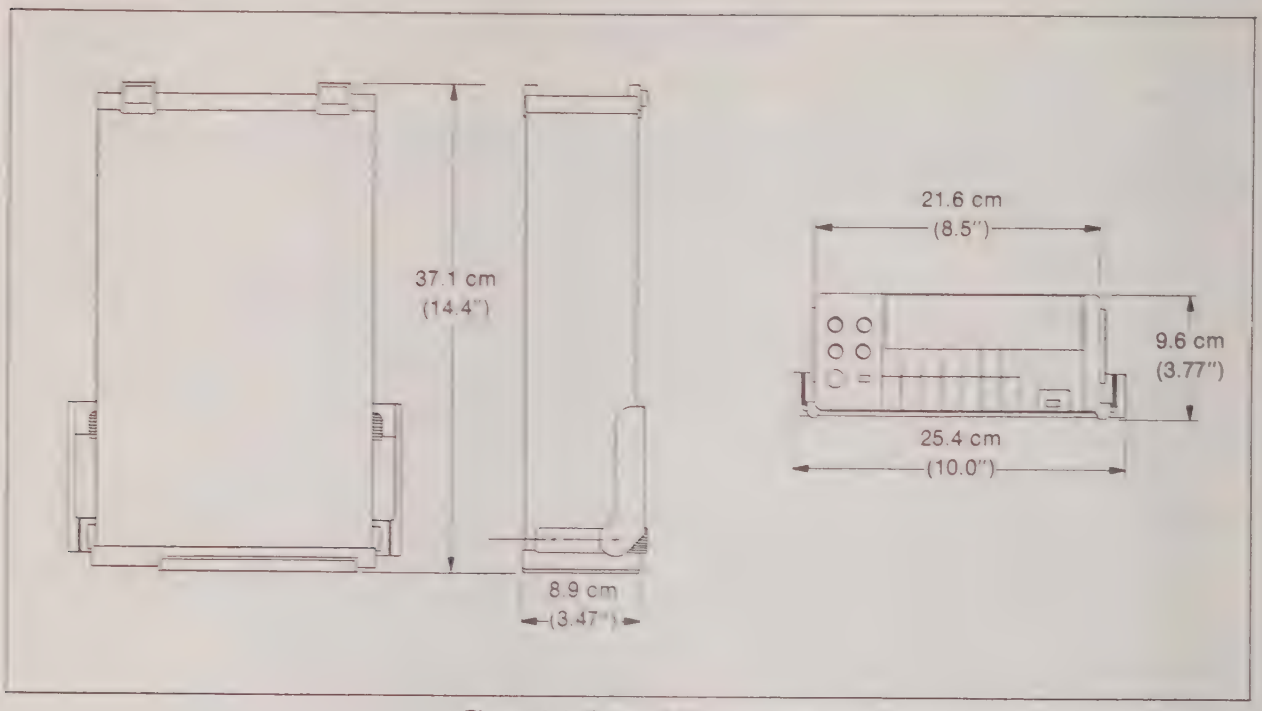


Figure 1-1. External Dimensions

Section 2
Operating Instructions

2-1. INTRODUCTION

This section provides instructions for installing and operating the 8840A. Refer to Section 4 for measurement considerations.

2-2. INSTALLATION

2-3. Installing the Power-Line Fuse

WARNING

FOR POWER-LINE VOLTAGES OF 198V TO 250V, THE POWER-LINE FUSE MUST BE REPLACED WITH A 1/8A, 250V SLOW-BLOW FUSE FOR FIRE PROTECTION. TO AVOID ELECTRIC SHOCK, REMOVE THE POWER CORD BEFORE REPLACING THE EXTERNAL LINE FUSE.

The 8840A has a rear-panel power-line fuse in series with the power supply. A 1/4A, 250V slow-blow fuse is installed in the factory for operation from 90V to 132V. For operation with power-line voltages of 198V to 250V, the fuse must be replaced with a 1/8A, 250V slow-blow fuse. (One is supplied with the instrument.)

To replace the power-line fuse, first remove the power cord. Then turn the rear-panel fuse cover 1/4-turn counterclockwise with a screwdriver.

For power-line voltages of 198V to 250V, use only a 1/4 x 1 1/4 (6.3mm x 32mm) fuse with at least a 100A breaking capacity.

2-4. Connecting to Line Power

WARNING

TO AVOID SHOCK HAZARD, CONNECT THE INSTRUMENT POWER CORD TO A POWER RECEPTACLE WITH EARTH GROUND. TO AVOID INSTRUMENT DAMAGE, CHECK THAT THE REAR PANEL LINE VOLTAGE SELECTION SWITCHES ARE SET TO THE POWER-LINE VOLTAGE IN YOUR AREA.

The 8840A can be configured to accept line power of 100, 120, 220, or 240V ac (±10%, 250V maximum) at 50, 60, or 400 Hz. The voltage must be selected by setting the rear panel LINE SET switches as shown in Figure 2-1. The 8840A automatically senses the power-line frequency at power-up, so that no adjustment for frequency is necessary.

2-5. Adjusting the Handle

The handle provides two viewing angles for bench-top use. To adjust its position, pull the ends out to a hard stop (about 1/4 inch on each side) and rotate it to one of the four stop positions shown in Figure 2-2. To remove the handle, adjust it to the vertical stop position and pull the ends all the way out.

2-6. Rack Mounting Kits

You can mount the 8840A in a standard 19-inch rack panel using the accessory rack mounting kits shown in Figure 2-3. To install the Single Rack Mount Kit, remove the handle and handle mounting plates, and attach the rack ears with the screws provided (Figure 2-4). The Dual Rack Mount Kit is installed similarly. (Both kits include mounting instructions.)

The rear feet may be rotated 180 degrees to clear a narrow rack space.

2-7. OPERATING FEATURES

2-8. Power-Up Features

When the 8840A is turned on, all display segments light up for about 2 seconds while the instrument performs an

internal self-test of its digital circuitry. The 8840A then assumes the following configuration:

- VDC function
- Autorange, starting in the 1000V range
- Slow reading rate
- Continuous, internal trigger
- OFFSET off
- Local (front panel) control

While all display segments are lit during the power-up self-test, you can freeze the display by pressing the SRQ button. All display segments will then remain lit until you press any button.

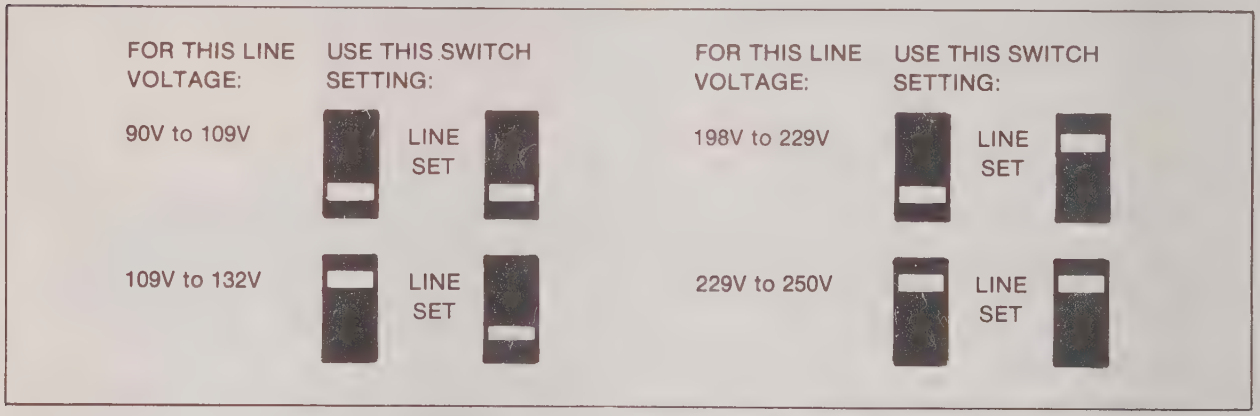


Figure 2-1. Line Voltage Selection Settings

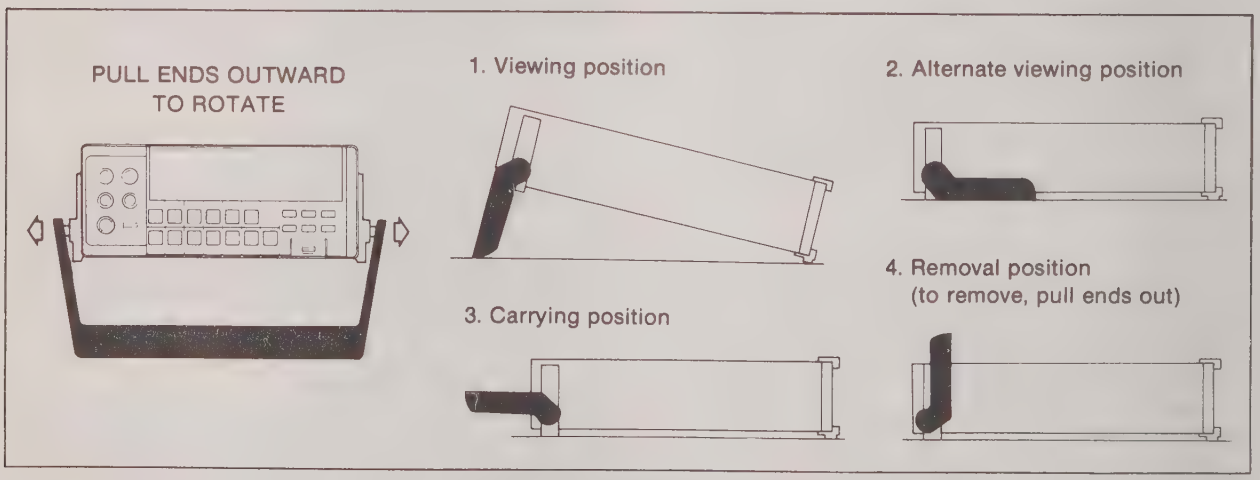


Figure 2-2. Adjusting the Handle

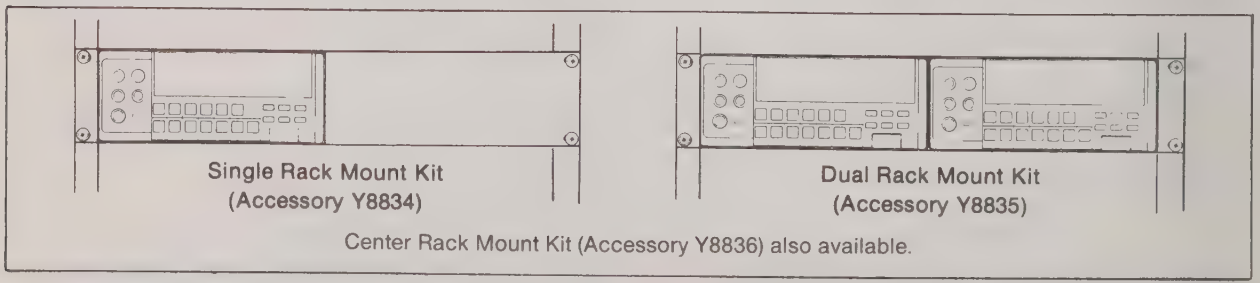

Single Rack Mount Kit
(Accessory Y8834)
Dual Rack Mount Kit
(Accessory Y8835)
Center Rack Mount Kit (Accessory Y8836) also available.

Figure 2-3. Rack-Mount Kits

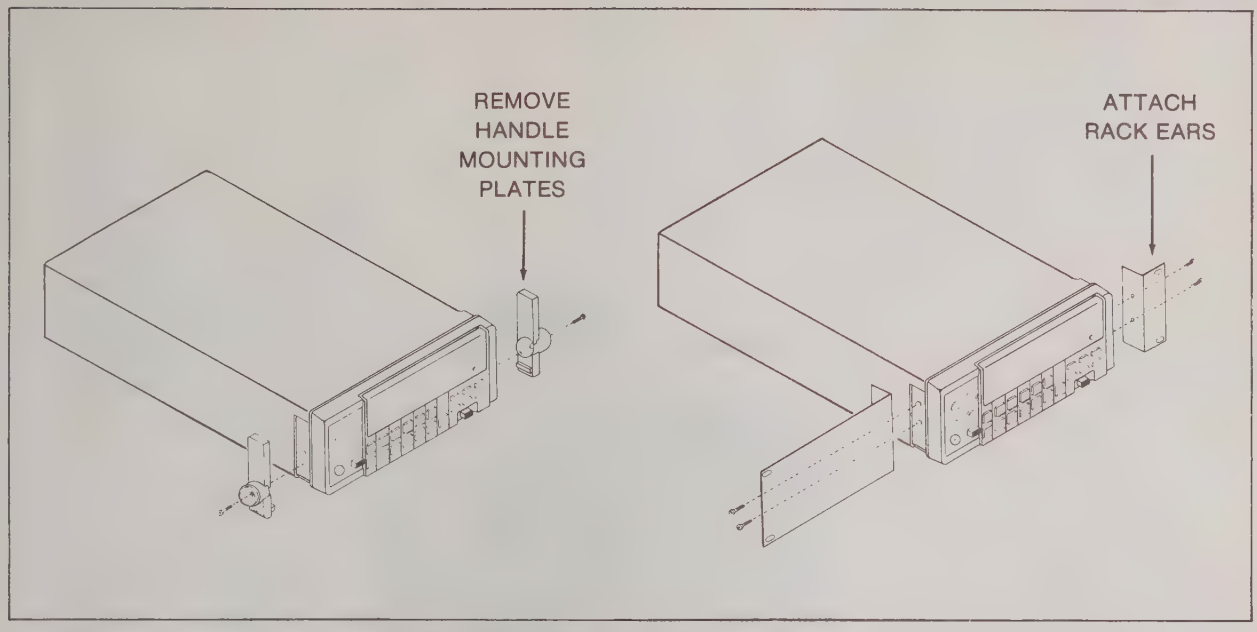


Figure 2-4. Installing the Single Rack Mount Kit

2-9. Front and Rear Panel Features

Front panel features are explained in Figure 2-5. Rear panel features are explained in Figure 2-6.

The alternate functions embossed below the front panel range buttons and the special feature buttons are enabled by the CAL ENABLE switch. These functions are for use only when calibrating the instrument. See the Maintenance section for further explanation.

CAUTION

To avoid accidentally uncalibrating the 8840A, do not press the CAL ENABLE switch unless calibrating the instrument. Never cycle power on or off while the CAL ENABLE switch is on.

Note that the VAC and mA AC functions are available only with the True RMS AC option. If this option is absent, pressing the VAC and mA AC function buttons causes the 8840A to briefly display an error message (ERROR 30).

2-10. Display Features

The 8840A features a vacuum fluorescent display with a numeric field and annunciators. The annunciators are explained in Figure 2-5.

2-11. Error Messages

If the 8840A detects an operator error or an internal failure, it displays an error message for about 2-1/2 seconds and then resumes normal operation. During this time, the front panel buttons are ignored. The error message consists of the ERROR annunciator and a two-digit error code. (See Figure 2-7.) Error codes are explained in Table 2-1.

If the FRONT/REAR switch is set to the REAR position while the mA DC or mA AC function is selected, ERROR 31 is displayed. In this case the error message is displayed until you return the switch to the FRONT position or select another function.

2-12. Overrange Indication

An input is overrange if it exceeds the full scale of the selected range. In most ranges, the 8840A indicates an input is overrange by lighting the OVER annunciator and showing a "1" on the display. (See Figure 2-8.) The sign, the position of the decimal point, and the other annunciators are not affected.

As a safety feature, the 8840A treats the 1000V dc and 700V ac ranges differently. In these ranges, the 8840A indicates when the input exceeds the input overload limit of 1000V dc or 700V ac, respectively, by lighting the OVER annunciator and flashing the display. Readings are still displayed.

2-13. Diagnostic Self-Tests

The 8840A features diagnostic self-tests which check both the digital and analog circuitry in the instrument. The self-tests consist of 21 analog tests followed by the in-guard program memory, calibration memory, and display self-tests. To initiate the self-tests, press the SRQ button for 3 seconds. The instrument can be stopped in any of the test configurations by pressing the SRQ button while the test number is displayed. Press any button to continue the tests.

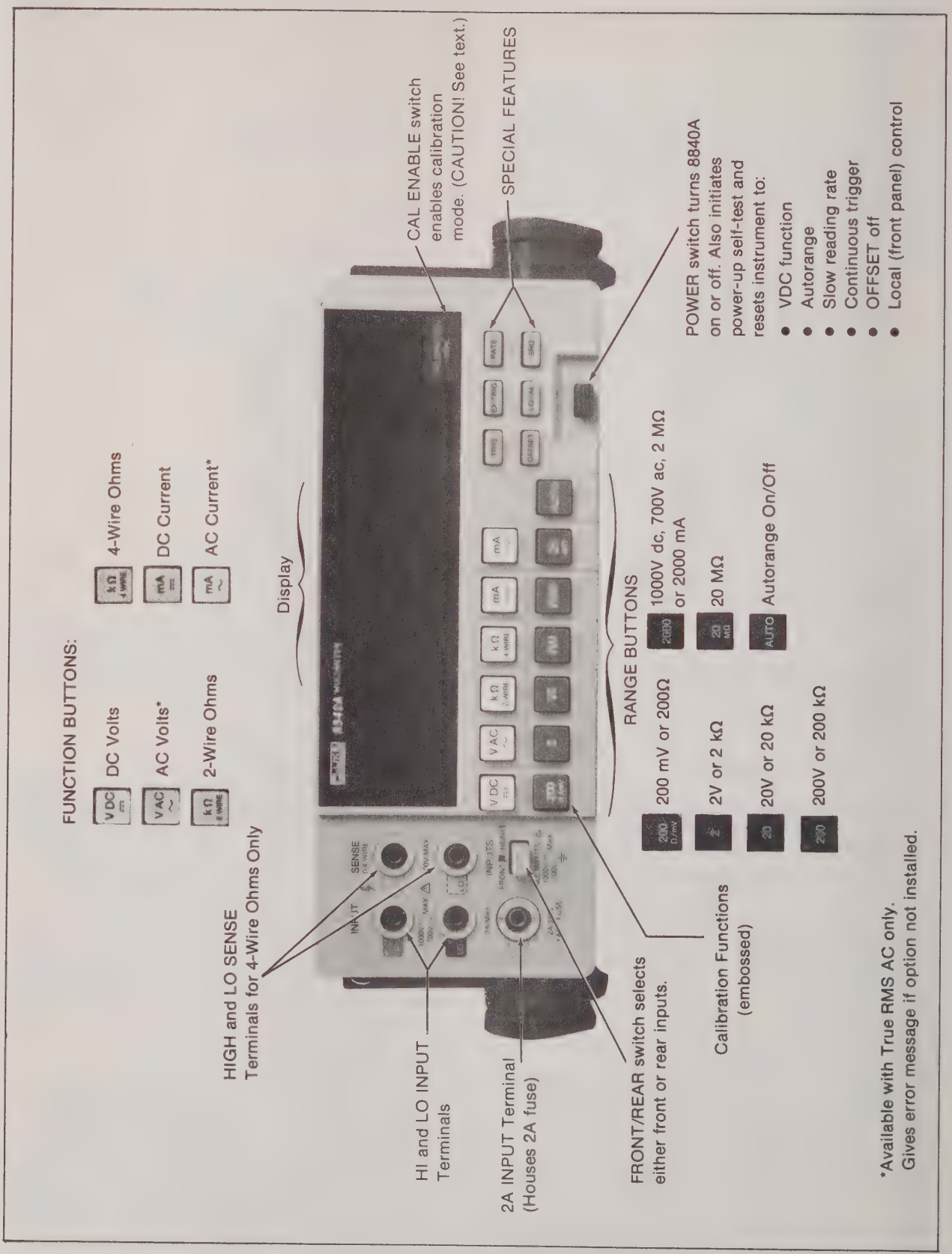
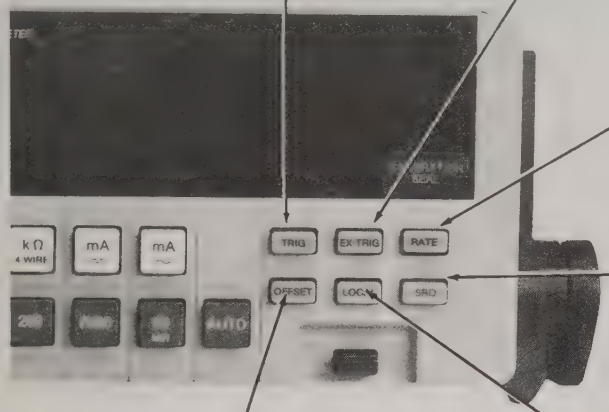

FUNCTION BUTTONS:
DC Volts
AC Volts*
2-Wire Ohms
4-Wire Ohms
DC Current
AC Current*
Display
CAL ENABLE switch enables calibration mode. (CAUTION! See text.)
SPECIAL FEATURES
HIGH and LO SENSE Terminals for 4-Wire Ohms Only
HI and LO INPUT Terminals
2A INPUT Terminal (Houses 2A fuse)
FRONT/REAR switch selects either front or rear inputs.
Calibration Functions (embossed)
RANGE BUTTONS
200 mV or 200Ω
2V or 2 kΩ
20V or 20 kΩ
200V or 200 kΩ
1000V dc, 700V ac, 2 MΩ or 2000 mA
20 MΩ
Autorange On/Off
POWER switch turns 8840A on or off. Also initiates power-up self-test and resets instrument to:
VDC function
Autorange
Slow reading rate
Continuous trigger
OFFSET off
Local (front panel) control
*Available with True RMS AC only.
Gives error message if option not installed.

Figure 2-5. Front Panel Features

TRIG triggers a new reading. Enabled in external trigger mode.

EXT TRIG toggles between internal and external trigger modes.

RATE cycles between slow, medium and fast reading rates. Automatically selects the optimum filter for each reading rate.



SRQ generates a service request over the IEEE-488 bus if enabled by the SRQ mask (IEEE-488 Interface option only). When pressed for 3 seconds, SRQ initiates diagnostic self-tests. NOTE: Leave inputs disconnected during self-tests or the 8840A may indicate errors.

If the 8840A is in remote, LOCAL returns it to local control. If the 8840A is in local, the LOCAL button causes the 8840A to display its bus address for two and one half seconds. Ignore if the IEEE-488 Interface is not installed.

OFFSET stores the displayed reading as an offset, which the 8840A subtracts from all subsequent readings in the function presently selected. Readings in the other functions remain unaffected. Pressing OFFSET again cancels the offset, or stores a new offset if in a different function.

Error Condition

Overrange

Calibration Mode Enabled

Reading Rate: Slow, Medium, and Fast. Blinks off when a reading is triggered.

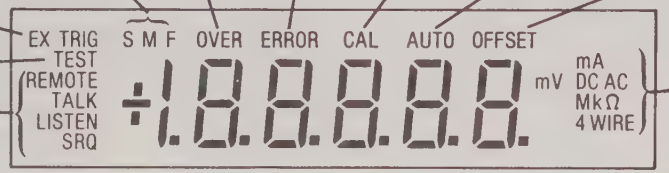
Autorange On

Offset on

External Trigger Mode Enabled

Self-Test Enabled

IEEE-488 Interface Annunciators



Function and Units Annunciators

Figure 2-5. Front Panel Features (cont)

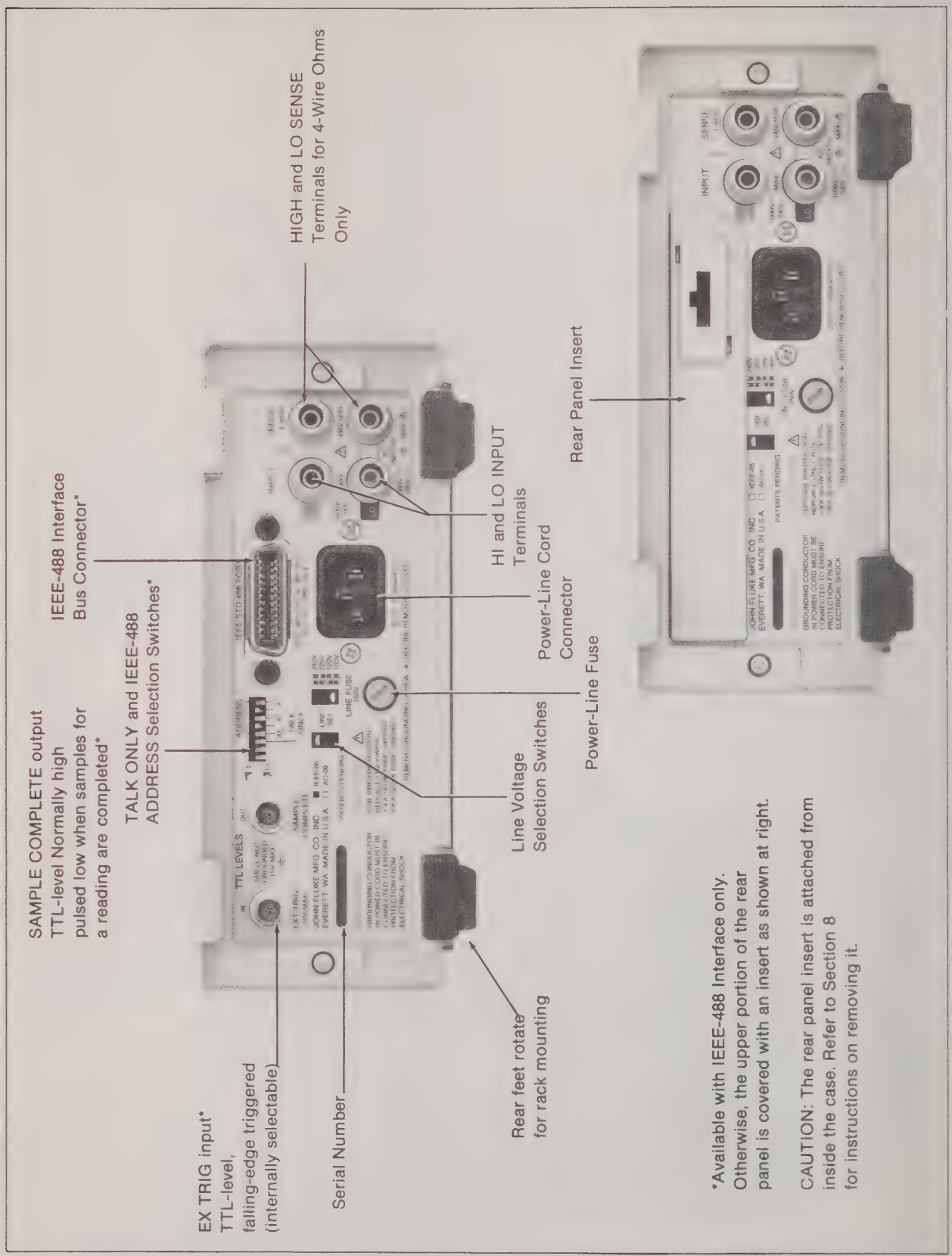
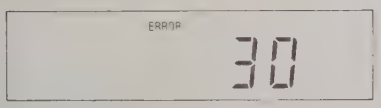
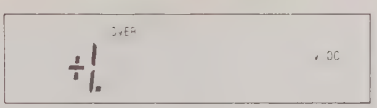


Figure 2-6. Rear Panel Features



Error 30: AC function selected without True RMS AC Converter option.

Figure 2-7. Typical Error Message



OVER: Input ≥2V dc in 2V range.

Figure 2-8. Overrange Indication

Table 2-1. Error Codes

ERROR CODE	MEANING	ERROR CODE	MEANING
	ANALOG SELF-TEST ERRORS		
1	200 VAC, Zero	40	Computed calibration constant out of range. (Previous cal may be wrong or there may be a hardware problem.)
2	700 VAC, Zero		
3	mA AC, Zero		
4	mA DC, Zero		
5	200 VDC, Zero	41	Calibration input out of acceptable range. Check that input is correct. (Previous cal may be wrong or there may be a hardware problem.)
6	1000 VDC, Zero		
7	1000 VDC + 20 MΩ		
8	20 VDC + 20 MΩ		
9	20 VDC + 2000 kΩ		
10	2 VDC + 2000 kΩ	42	Calibration memory write error. (Probably a hardware problem.)
11	200Ω, Overrange		
12	2 kΩ, Overrange		
13	20 kΩ, Overrange	50	Guard crossing error detected by In-Guard μC.
14	200 kΩ, Overrange		
15	1000 VDC + X10 T/H + 20 MΩ	51	Calibration command not valid unless calibration mode is enabled.
16	200 VDC + 200 kΩ		
17	200 VDC + 20 kΩ		
18	200 VDC + 2 kΩ	52	Command not valid at this time.
19	200 VDC, Filter On		
20	200 VDC + 2 kΩ, Filter Off	53	Invalid calibration value in Put command. (Example: Sending a negative value during ac calibration.)
21	200 VDC, Filter Off		
	DIGITAL SELF-TEST ERRORS		
25	In-Guard μC Internal RAM	54	Command not valid in calibration verification.
26	Display RAM		
27	In-Guard μC Internal Program Memory	56	Variable inputs not allowed during A/D calibration. Use prompted value.
28	External Program Memory		
29	Calibration Memory	60	Device-dependent commands not valid during self-tests.
	OPERATION ERRORS	71	Syntax error in device-dependent command string.
30	AC functions available only with True RMS AC option.	72	Guard crossing error detected by Out-Guard μC.
31	mA AC or mA DC function selected while REAR inputs selected.	77	IEEE-488 Interface self-test error.
32	OFFSET selected while reading is unavailable or overrange.		

NOTE: See the Maintenance section for a detailed description of self-tests.

During the test, the TEST annunciator lights, and the numeric field displays the number of each analog test as it is performed. Then all display segments light up while the instrument performs the in-guard program memory, calibration memory, and display self-tests. The 8840A then returns to the power-up configuration. The self-tests are described in greater detail in the Maintenance section.

NOTE

The inputs must be left disconnected while the self-tests are performed or the 8840A may indicate that errors are present.

If the 8840A detects an error, it displays an error message for about 2-1/2 seconds. (Error codes 01 through 29 correspond to the self-tests.) If self-test errors are displayed even when the input terminals are disconnected, there may be a hardware problem in your 8840A. In that event, refer to the Maintenance section or contact your local Fluke representative.

2-14. Ranging

Measurement ranges can be selected using either autorange (by pressing the AUTO button) or manual range (by pressing another range button). The 8840A displays explicit units in every range, so that the display may be read directly.

2-15. AUTORANGE

In autorange, the 8840A goes to a higher range when the input exceeds full scale (199999 counts), and goes to a lower range when the input falls below 9% of full scale (18000 counts). While the instrument changes range, the numeric field on the display is blanked until a new reading is completed. However, the decimal point and units annunciators always indicate what range the instrument is in.

Pressing the AUTO button when the instrument is already in autorange toggles the 8840A from autorange to manual range. This causes the instrument to remain locked in the present range.

2-16. MANUAL RANGE

In manual range, the 8840A remains fixed in the selected range until you select another range or press AUTO. If you select a range which is not valid for the present function, or select a function which is not valid for the present range, the 8840A selects the nearest valid range. For example, if the 8840A is in the VDC function and you press the 20 MΩ button, the 8840A selects the 1000V range.

The range buttons have no effect in the mA DC and mA AC functions, since all measurements in these functions are made in the 2000 mA range.

2-17. Triggering

Triggering causes the 8840A to execute a measurement cycle and display the result. During each measurement cycle, the instrument samples the input a number of times and then averages the samples to compute a reading. The number of samples averaged for each reading depends upon the reading rate.

Each time a reading is triggered, the rate annunciator (S, M, or F) blinks off. In the fast reading rate, the F annunciator flashes so rapidly it appears to be almost constant.

How the 8840A is triggered depends on whether the continuous trigger mode or external trigger mode is selected. Pressing the EX TRIG (external trigger) button toggles the 8840A between the two modes.

2-18. CONTINUOUS TRIGGER MODE

In the continuous trigger mode, readings are triggered by a continuous, internal trigger. The rate of the trigger is set by the RATE button.

2-19. EXTERNAL TRIGGER MODE

In the external trigger mode, readings are triggered by pressing the TRIG button. If the IEEE-488 Interface option is installed, readings can also be triggered by remote commands or by using the rear panel external trigger (EXT TRIG) connector. (See the Options and Accessories section.)

In the external trigger mode, pressing any front panel button blanks the numeric field on the display until a new measurement is triggered. This ensures that all readings correspond to the instrument configuration indicated by the display annunciators. The blanking also occurs in the continuous trigger mode, but usually isn't noticed because new measurements are triggered automatically.

The TRIG button does not trigger readings in the continuous trigger mode. However, it does blank the last reading to acknowledge a button was pressed.

2-20. Reading Rates and Noise Rejection

The RATE button allows you to optimize either measurement speed or noise rejection. The 8840A uses both analog and digital filtering to allow measurements in the presence of unwanted environmental noise (especially line-related noise). However, since filtering introduces a delay in response to a change in the input signal, there is an inherent trade-off between noise rejection and measurement speed.

The instrument has three reading rates: slow (S) and medium (M), with a 5-1/2 digit display, and fast (F), with a 4-1/2 digit display. To provide optimum combinations

of measurement speed and noise rejection, the RATE button allows control of both the internal trigger rate and the degree of filtering. The same degree of filtering is used in both the continuous and external trigger modes.

In the continuous trigger mode, the actual number of readings displayed per second for each reading rate is determined by the line-power frequency. At power-up, the 8840A senses the line-power frequency and adjusts the analog-to-digital converter timing characteristics for optimum normal-mode noise rejection. The resulting reading rates are shown in the specifications in Section 1.

2-21. Automatic Settling Time Delay

When the external trigger mode is selected, the 8840A automatically inserts a delay after receiving a trigger signal, but before starting the first input sample. The delay is just long enough so that the reading will be correct (within a specified number of counts of the final value) even if the trigger signal occurs as the input makes a step change between zero and full scale (10,000 counts and full scale in the ac functions). For resistance measurements, the delay also allows for settling when the step change is made from an open circuit to an in-range value.

The length of the delay depends on the range, function, and reading rate, as shown in the specifications in Section 1. The delay is enabled only in the external trigger mode. It can be turned off with a remote command over the IEEE-488 interface bus to accommodate special timing considerations.

2-22. External Trigger Input (Option -05 Only)

The rear panel EXT TRIG input is a TTL-level input which can be used to trigger measurements when the 8840A is in the external trigger mode. A measurement is triggered on the falling edge of the input. Since the EXT TRIG input is pulled high internally, it can also be controlled by a normally open switch. A measurement is triggered when the switch is closed.

For special applications using the IEEE-488 Interface, the automatic setting time delay can be disabled using remote commands. (See Section 3.) Refer to Section 1 for timing details.

The polarity of the EXT TRIG input can be reversed by changing internal jumpers. Refer to the Maintenance section for instructions.

2-23. Sample Complete Output (Option -05 Only)

The SAMPLE COMPLETE output indicates when analog input sampling for a reading is completed. The output is a TTL-level signal which is pulsed low for approximately 2.5 us when the input-sampling portion of the A/D conversion is completed. The signal is useful for interfacing with other equipment when the 8840A is used in external trigger mode in an instrumentation system. For example, the SAMPLE COMPLETE output could be used to advance a scanner to the next channel.

2-24. MAKING MEASUREMENTS

2-25. Input Overload Protection Limits

WARNING

TO AVOID SHOCK HAZARD AND/OR INSTRUMENT DAMAGE, DO NOT APPLY INPUT POTENTIALS THAT EXCEED THE INPUT OVERLOAD LIMITS SHOWN IN TABLE 2-2.

The 8840A is protected against input overloads up to the limits shown in Table 2-2. Exceeding these limits may damage the instrument and or pose a shock hazard.

Table 2-2. Input Overload Limits

FUNCTION	CONNECTORS	MAXIMUM INPUT
VDC	INPUT HI and LO:	1000V dc
mA DC	2A INPUT and INPUT LO:	2000 mA
2 WIRE/4 WIRE kΩ	INPUT HI and LO: SENSE HI and LO:	300V rms 300V rms
VAC	INPUT HI and LO:	700V rms, 1000V peak, or 2×10^7 V-Hz (whichever is less)
mA AC	2A INPUT and INPUT LO:	2000 mA rms
All Functions	Any terminal to earth:	1000V dc or peak ac

2-26. Measuring Voltage and Resistance

To measure voltage or resistance, select the desired function and connect the test leads as shown in Figure 2-9. Resistance can be measured in either the 2-wire or 4-wire configuration.

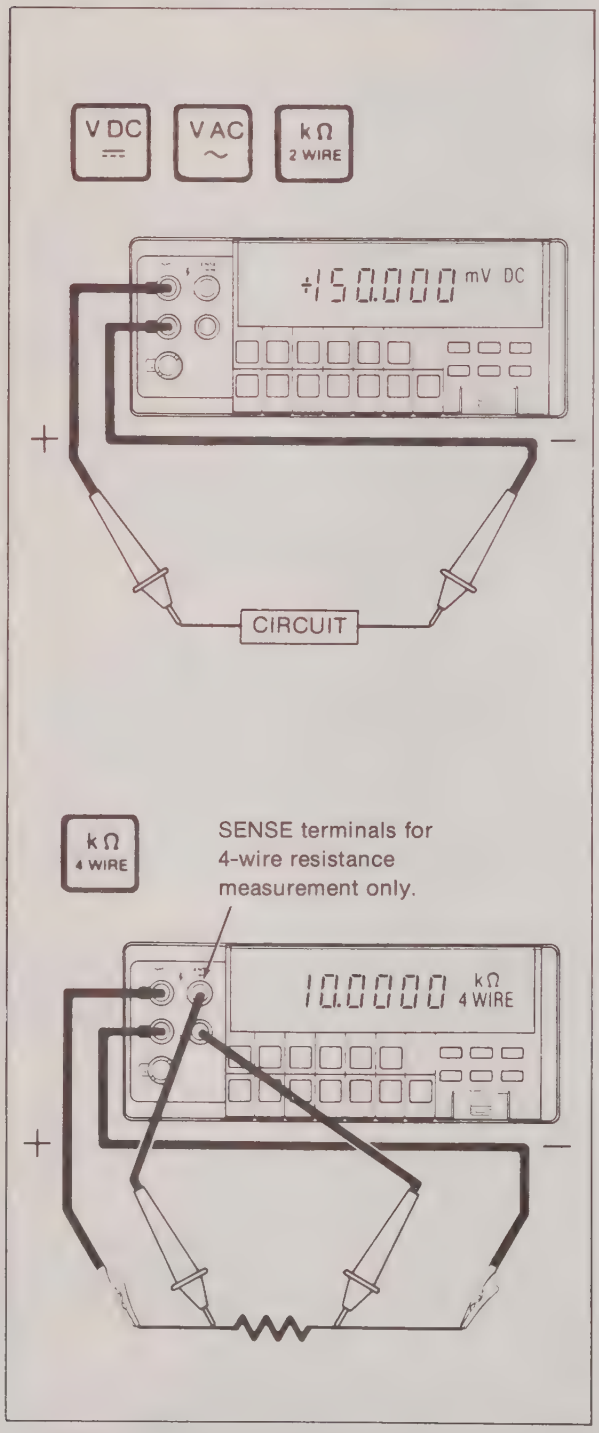


Figure 2-9. Measuring Voltage and Resistance

2-27. Measuring Current

To measure current, select the desired function and connect the test leads as follows:

1. Turn off power in the circuit to be measured (Figure 2-10).
2. Break the circuit (preferably on the ground side to minimize the common mode voltage), and place the 8840A in series at that point.
3. Turn on power in the circuit, and read the display.
4. Turn off power in the circuit, and disconnect the 8840A.

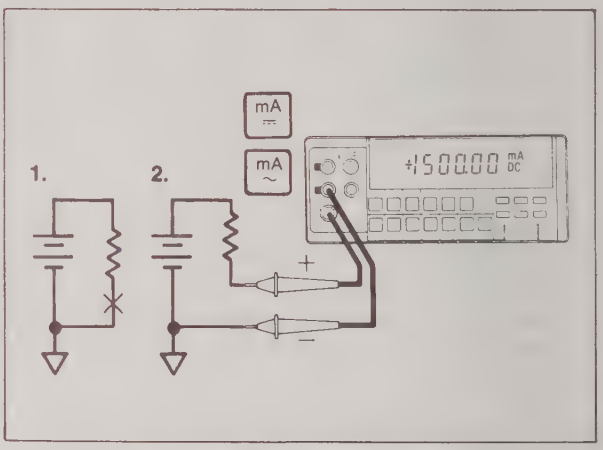


Figure 2-10. Measuring Current

2-28. Current Fuse Protection

The 2A input terminal is protected from overloads by a 2A, 250V fuse which is accessible from the front panel, and by an internal 3A, 600V fuse. If either fuse blows, the 8840A will respond as though the input were zero.

WARNING

TO AVOID ELECTRIC SHOCK, REMOVE THE TEST LEADS BEFORE REPLACING THE FRONT PANEL FUSE.

To replace the front panel fuse, first remove the test leads. Then press in the lip of the 2A input terminal slightly and rotate it 1/4-turn counterclockwise. Spring tension will force the fuse and fuse holder out of the front panel. The internal 3A fuse should be replaced only by qualified service personnel.

2-29. Offset Measurements

WARNING

WHEN THE OFFSET FEATURE IS IN USE, DISPLAYED READINGS ARE RELATIVE AND MAY NOT INDICATE THE PRESENCE OF DANGEROUS POTENTIALS AT THE INPUT CONNECTORS OR TEST LEADS. USE CAUTION TO AVOID ELECTRIC SHOCK OR INSTRUMENT DAMAGE.

The OFFSET feature allows you to store a reading as a relative reference value. When the OFFSET button is pressed, the 8840A stores the present reading and displays subsequent measurements as the difference between the measured value and the stored reading. The OFFSET annunciator is lit whenever an offset is in use.

The OFFSET feature may be used in all functions. Since the display represents a numeric difference, it always has a sign, even in the resistance and ac functions.

The offset can be cancelled by pressing the OFFSET button again, in which case the OFFSET annunciator disappears from the display. The offset can also be cancelled by storing an offset in another function. If a reading is overrange or unavailable when the OFFSET button is pressed, the 8840A indicates ERROR 32 and does not store the offset.

If you change functions while an offset is stored, the OFFSET annunciator disappears and the offset temporarily disappears. However, when you return to the original function, the offset is restored (and the OFFSET annunciator reappears) unless a new offset was established in another function.

Note that the input overload limits are not changed by the use of the offset feature. However, the display flashes if the 8840A is in the 1000V dc or 700V ac ranges and the input exceeds 1000V dc or 700V ac, respectively.

While an offset is enabled, the 8840A indicates an overrange condition if either of the following conditions occur:

- The input signal is overrange
- The calculated reading is overrange

For example, suppose the instrument is in the 20V range of the VDC function and you store an offset of +15V. The maximum positive voltage reading that can be displayed without overranging is +4.9999V, which is actually a +19.9999V input signal. The maximum negative voltage reading that can be displayed without overranging is -19.9999V, which is actually a -4.9999V input signal. You can measure a greater range of voltages by selecting a higher range.

When in autorange, the 8840A selects the range appropriate for the input signal, regardless of any stored offset. If, for example, a +10V offset is stored, and a +1V input is applied, the 8840A will autorange to the 2V range and display an overrange condition since it cannot display -9V on the 2V range. Manual range control could be used to lock the 8840A into the 20V range in this case.

Applications of the offset feature include correcting for test lead resistance in 2-wire resistance measurements, nulling offset currents or voltages, measuring voltage deviations, and matching resistors.

2-30. EXTERNAL CLEANING

WARNING

TO AVOID ELECTRIC SHOCK OR INSTRUMENT DAMAGE, NEVER GET WATER INSIDE THE CASE. TO AVOID INSTRUMENT DAMAGE, NEVER APPLY SOLVENTS TO THE INSTRUMENT.

Should the 8840A case require cleaning, wipe the instrument with a cloth that is lightly dampened with water or a mild detergent solution.

Section 3
Remote Programming

NOTE

This section contains programming instructions for use with the IEEE-488 Interface (Option -05). For installation instructions, refer to the Options and Accessories section.

3-1. INTRODUCTION

The IEEE-488 Interface turns the 8840A into a fully programmable instrument for use with the IEEE Standard 488-1978 interface bus (IEEE-488 bus). With the IEEE-488 Interface, the 8840A can become part of an automated instrumentation system. The 8840A can be under complete, interactive control from a remote bus controller; or it can be set to the talk-only mode, connected to a data logger or printer, and dedicated to a single task.

This manual assumes you know the basics of the IEEE-488 interface bus. For an introduction to the bus, request Fluke Application Bulletin AB-36, "IEEE Standard 488-1978 Digital Interface for Programmable Instrumentation."

3-2. CAPABILITIES

The IEEE-488 Interface provides remote control of all front panel controls except for the POWER, CAL ENABLE, and FRONT/REAR switches. Other features include:

- A simple and predictable command set
- Fast measurement throughput
- Full talk/listen capability, including talk-only operation
- Full serial poll capability, with bit-maskable SRQ
- Full remote/local capability, including local lockout
- EXTERNAL TRIGGER and SAMPLE COMPLETE connectors
- Remote calibration
- Programmable trigger sources, including two bus triggers
- Informative output suffix (suppressible)
- Selectable output terminators

The 8840A supports the following interface function subsets: SH1, AH1, T5, L4, SR1, RL1, DC1, DT1, E1, PP0, and C0.

3-3. BUS SET-UP PROCEDURE

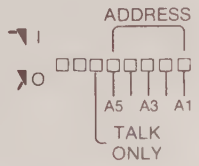
To set up the 8840A on the IEEE-488 bus, proceed as follows:

1. Turn the 8840A POWER switch OFF and set the 8840A IEEE-488 address using the rear panel IEEE-488 address switches shown in Figure 3-1.
2. Plug the IEEE-488 cable into the 8840A rear panel IEEE-488 connector.
3. Switch on the 8840A.

Whenever the 8840A is in the local state, the IEEE-488 address can be displayed on the front panel by pressing the LOCAL button.

3-4. AN OVERVIEW OF REMOTE OPERATION

An overview of remote operation is presented in the block diagram in Figure 3-2. Each block represents a register, buffer, etc., contained in the 8840A. The status registers in the center column indicate the instrument's status, including its function, range, reading rate, etc. The input buffer receives data from the IEEE-488 bus. The output buffer receives data from the blocks to its left, and sends data on to the IEEE-488 bus.



ADDRESS	TALK ONLY	A5	A4	A3	A2	A1
00	0	0	0	0	0	0
01	0	0	0	0	0	1
02	0	0	0	0	1	0
03	0	0	0	0	1	1
04	0	0	0	1	0	0
05	0	0	0	1	0	1
06	0	0	0	1	1	0
07	0	0	0	1	1	1
08	0	0	1	0	0	0
09	0	0	1	0	0	1
10	0	0	1	0	1	0

ADDRESS	TALK ONLY	A5	A4	A3	A2	A1
11	0	0	1	0	1	1
12	0	0	1	1	0	0
13	0	0	1	1	0	1
14	0	0	1	1	1	0
15	0	0	1	1	1	1
16	0	1	0	0	0	0
17	0	1	0	0	0	1
18	0	1	0	0	1	0
19	0	1	0	0	1	1
20	0	1	0	1	0	0
21	0	1	0	1	0	1

ADDRESS	TALK ONLY	A5	A4	A3	A2	A1
22	0	1	0	1	1	0
23	0	1	0	1	1	1
24	0	1	1	0	0	0
25	0	1	1	0	0	1
26	0	1	1	0	1	0
27	0	1	1	0	1	1
28	0	1	1	1	0	0
29	0	1	1	1	0	1
30	0	1	1	1	1	0
31	Not allowed					
TALK ONLY	1	X	X	X	X	X

X = setting does not matter

Figure 3-1. IEEE-488 Address Selection

Information is transferred between blocks by device-dependent commands. Each command is shown next to an arrowhead which indicates the resulting information transfer. For example, Put command P0 takes a number from the input buffer and stores it in the primary status registers. Likewise, Get command G0 gets the content of the primary status registers and copies it into the output buffer.

3-5. A NOTE ABOUT EXAMPLES

In the examples in this manual, device-dependent commands are shown enclosed within quotation marks, as they would be entered in Fluke BASIC. For clarity, the commands are also separated by spaces. However, the spaces are are not necessary and may be omitted.

Example	*Explanation*
"* F3 R1 S1 T2"	This example is equivalent to "*F3R1S1T2" or "*,F3,R1,S1,T2".

Using the Fluke 1722A Instrument Controller, these commands might be written into a BASIC program as shown in Figure 3-3. Examples using other controllers are given at the end of this section.

Examples of 8840A output data show the terminators CR and LF. The terminator EOI is not shown because it is a uniline message. However, the terminators CR, LF, and EOI are all selectable using the Write commands.

For reference, the ASCII and IEEE Std 488-1978 bus codes are shown at the back of this section.

3-6. DEVICE-DEPENDENT COMMAND SET

Device-dependent commands are the heart of 8840A remote control. They tell the 8840A how and when to make measurements, when to put data on the bus, when to make service requests, etc. Commands which correspond directly to the front panel controls or display are shown in Figure 3-4. The complete set of device-dependent commands is listed in Figure 3-5. The commands may be entered using either upper- or lower-case letters. See table 6-15 for conditions under which certain commands are not valid.

Device-dependent commands are device-dependent messages. For the 8840A to receive them, they must be sent over the IEEE-488 bus when the 8840A is in remote and has been addressed as a listener.

The following paragraphs describe the device-dependent commands in alphabetical order. Special characters (* and ?) are described last.

3-7. Bn (Offset Commands)

The Offset commands duplicate the function of the front panel OFFSET button. When the 8840A receives the B1 command, the 8840A stores the present reading as an offset for the present function. The B0 command cancels the offset. As with front panel operation, only one offset is allowed at a time.

The offset status (not the offset value) can be read using the G5 command. The 8840A defaults to B0 on both power-up and on any device-clear command (*, DCL, or SDC).

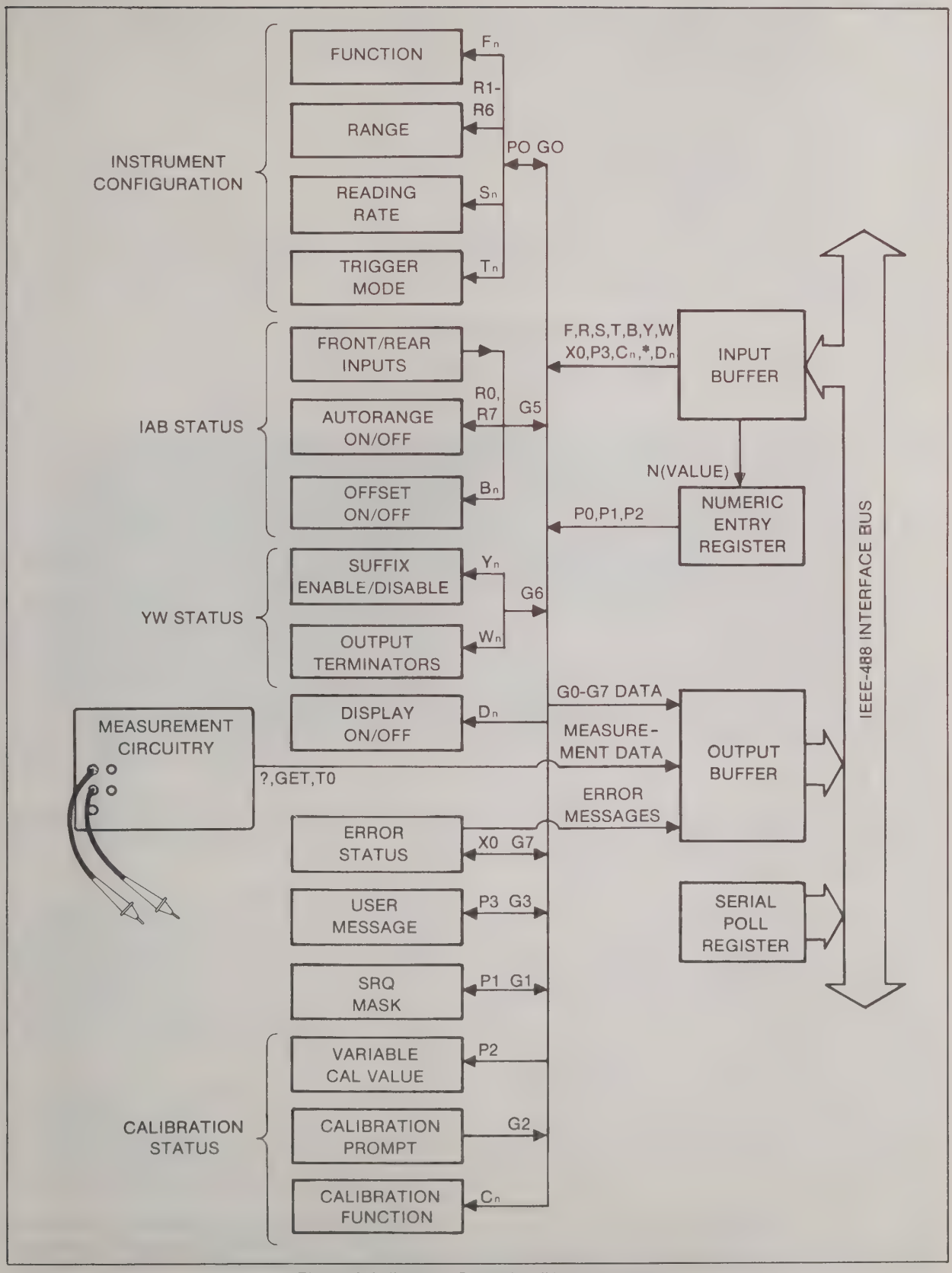


Figure 3-2. Remote Operation Block Diagram

Here is a typical command string as it might be sent from a Fluke 1722A Instrument Controller. The string configures the 8840A and triggers a reading. The PRINT command automatically sends terminators (CR, LF, and/or EOI) to the 8840A at the end of the command string.

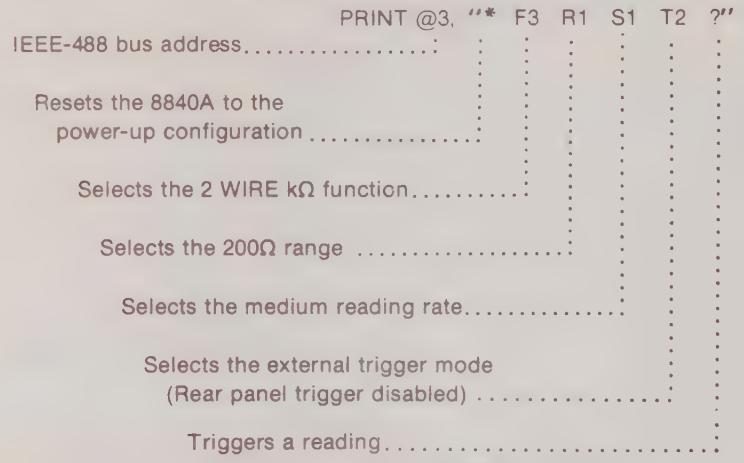

PRINT @3, "* F3 R1 S1 T2 ?"
IEEE-488 bus address
Resets the 8840A to the power-up configuration
Selects the 2 WIRE kΩ function
Selects the 200Ω range
Selects the medium reading rate
Selects the external trigger mode (Rear panel trigger disabled)
Triggers a reading

Figure 3-3. Typical Command String

3-8. Cn (Calibration Commands)

CAUTION

The command string "C3 C0" erases the entire calibration memory. A complete calibration must then be performed.

The Calibration commands allow the 8840A to be calibrated under remote control. Commands C0, C1, and C2 duplicate the front panel calibration functions STORE, A/D, and HF AC, respectively. For a complete description of remote calibration, see the Maintenance section of this manual.

For the 8840A to accept these commands, the 8840A must be in the calibration mode (enabled by pressing the front panel CAL ENABLE switch). Otherwise, the commands generate an error message.

3-9. Dn (Display Commands)

The Display commands allow the user to blank the numeric field in the 8840A front panel display. The D0 command causes the display to operate normally, and is the default on power-up and upon any device-clear command (*, DCL, or SDC).

The D1 command blanks the numeric field in the display. The annunciators remain active, and all of the annunciators still flash if the input exceeds 1000V dc or 700V ac in the respective ranges. The D1 command is used for best performance when high IEEE-488 Interface Data rates are required.

3-10. Fn (Function Commands)

The function commands duplicate the front panel function buttons. The 8840A defaults to F1 on power-up and on any device-clear command (*, DCL, or SDC). If F0 is sent to the 8840A, it is internally converted to F1. The function setting can be read using the G0 command.

As with the front panel commands, selecting F5 or F6 automatically selects the 2000 mA range (R5). Also, if the instrument is in a resistance function (F3 or F4) and in R6, selecting any other function automatically selects R5.

Example	*Explanation*
"F3"	Selects 2 WIRE kΩ function; it does not affect any other settings.
"* F5"	Selects mA DC function and 2000 mA range. Resets all other settings to default

3-11. Get Commands

The Get commands "get" information from the 8840A for the controller. Each Get command loads the output buffer with an output string in the format shown in Figure 3-6. Status data (the output from Get commands G0, G1, G3, G4, G5, G6, and G7) is interpreted as shown in Table 3-1. The Get commands should not be confused with the interface message GET (Group Execute Trigger).

The output data from some Get commands starts with a leading 1 or 10. This prevents the controller from suppressing leading zeroes and gives a uniform four-character length to all instrument configuration data (the data from Get commands G0, G4, G5, G6, and G7).

The Get commands are described further in the following paragraphs. For more information about output data, see paragraph 3-39.

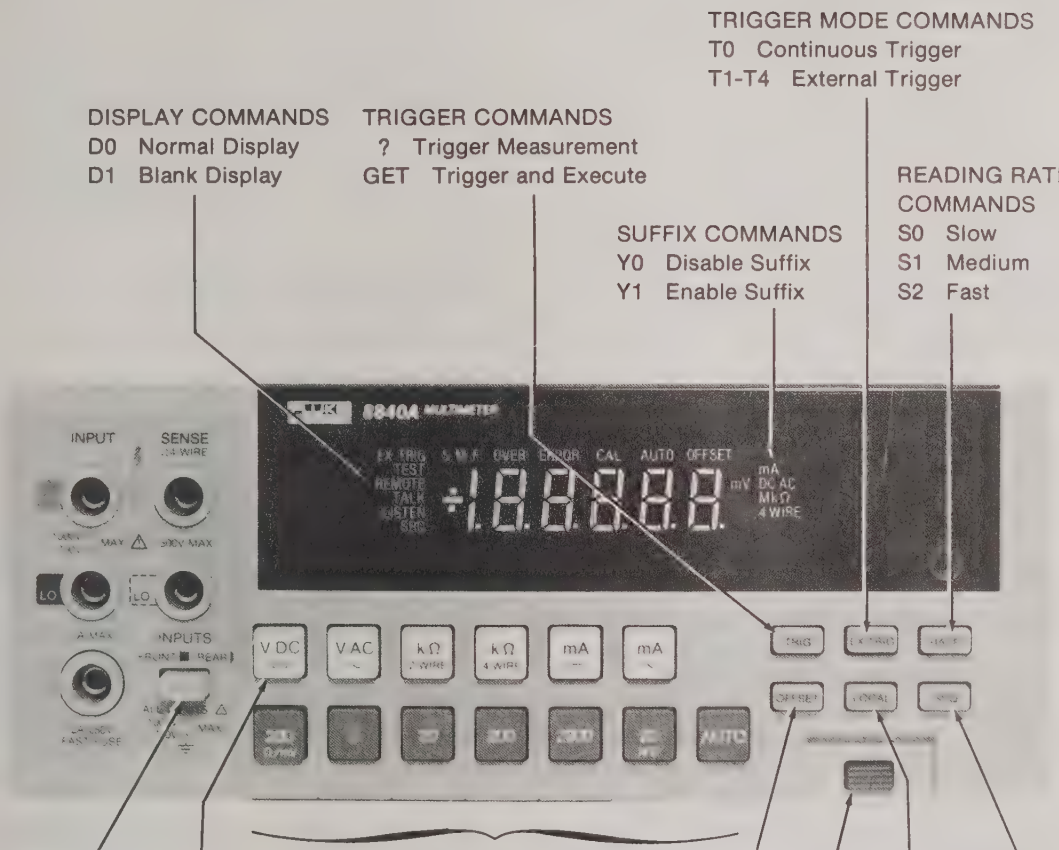


Figure 3-4. Commands Which Correspond to the Front Panel

FUNCTION COMMANDS

F1 VDC (Default)
F2 VAC
F3 2 WIRE kΩ
F4 4 WIRE kΩ
F5 mA DC
F6 mA AC

RANGE COMMANDS

R0 Autorange On (Default)
R1 200 mV, 200Ω
R2 2V, 2 kΩ
R3 20V, 20 kΩ
R4 200V, 200 kΩ
R5 1000V dc, 700V ac, 2 MΩ, 2000 mA
R6 20 MΩ
R7 Autorange Off

READING RATE COMMANDS

S0 Slow (Default)
S1 Medium
S2 Fast

TRIGGER MODE COMMANDS

COMMAND	TRIGGER MODE	REAR PANEL TRIGGER	SETTLING DELAY
T0 (Default)	Internal	Disabled	—
T1	External	Enabled	On
T2	External	Disabled	On
T3	External	Enabled	Off
T4	External	Disabled	Off

Note: Delay is enabled by entering EX TRIG mode while in local.

OFFSET COMMANDS

B0 Offset Off (Default)
B1 Offset On

DISPLAY COMMANDS

D0 Normal Display (Default)
D1 Blank Display

SUFFIX COMMANDS

Y0 Disable Output Suffix (Default if talker/listener)
Y1 Enable Output Suffix (Default in talk-only mode)

TERMINATOR COMMANDS

W0 Enable CR LF EOI (Default)
W1 Enable CR LF Only
W2 Enable CR EOI Only
W3 Enable CR Only
W4 Enable LF EOI Only
W5 Enable LF Only
W6 Enable EOI Only
W7 Disable All Output Terminators

CLEAR COMMANDS

* Device Clear (Resets 8840A to default conditions)
X0 Clear Error Register

SINGLE-TRIGGER COMMAND

? Trigger Measurement

GET COMMANDS

G0 Get Instrument Configuration (F,R,S, and T)
G1 Get SRQ Mask
G2 Get Calibration Input Prompt
G3 Get User-Defined Message
G4 Get Calibration Status
G5 Get IAB Status (Input F/R, Autorange On/Off, Offset On/Off)
G6 Get YW Status (Suffix Enabled/Disabled, Terminator Selection)
G7 Get Error Status

Note: G2 valid only in calibration mode.

PUT COMMANDS

P0 Put Instrument Configuration (F,R,S, and T)
P1 Put SRQ Mask
P2 Put Variable Calibration Value
P3 Put User-Defined Message

Note: P2 and P3 valid only in calibration mode.

PUT COMMAND FORMAT

N ⟨value⟩ P0
N ⟨value⟩ P1
N ⟨value⟩ P2
P3 ⟨16 ASCII characters⟩

Figure 3-5. Device-Dependent Command Set

SRQ MASK VALUES

00 for SRQ Disabled (Default)
01 for SRQ On Overrange
04 for SRQ On Front Panel SRQ
08 for SRQ On Cal Step Complete
16 for SRQ On Data Available
32 for SRQ On Any Error

Note: Add SRQ mask values for combinations.
Example: 33 for SRQ on overrange or any error.

SELF-TEST COMMAND

Z0 Begin Self-Tests

CALIBRATION COMMANDS

C0 Store Present Input as Calibration Value
C1 Begin A/D Calibration
C2 Begin HF AC Calibration
C3 Enter Erase Mode (CAUTION! The command string "C3 C0" erases the entire calibration memory. A complete calibration must then be performed.

Note: C0 through C3 are valid only in calibration mode

TERMINATORS

CR	(Carriage Return)	Execute
LF	(Line Feed)	Execute
EOI	(End Or Identify)	Execute
GET	(Group Execute Trigger)	Trigger and execute

Note: GET is an interface message.

Figure 3-5. Device-Dependent Command Set (cont)

3-12. G0 (Get Instrument Configuration)

The G0 command copies the 8840A function, range, reading rate, and trigger mode into the output buffer in the format shown in Figure 3-6. The four digits returned represent the arguments for the equivalent F, R, S, and T commands, as shown in Table 3-1. An example output string follows.

Example	*Meaning*
3410 CR LF	3: F3 (2 WIRE kΩ function)
	4: R4 (200 kΩ range)
	1: S1 (Medium reading rate)
	0: T0 (Continuous trigger)

The second digit, which can vary from 1 to 6, indicates what measurement range the 8840A is in regardless of whether the 8840A is in autorange or manual range.

The output string from a G0 command is acceptable as an argument for an "N" command. This allows you to configure the 8840A from the front panel and then record the configuration over the bus for future use with a P0 command. However, 9mmm (meaning self-test) can not be used with the P0 command.

3-13. G1 (Get SRQ Mask)

The G1 command copies the present SRQ mask into the output buffer in the format shown in Figure 3-6. The SRQ mask values are explained in Table 3-1. An example output string follows. For more about the SRQ mask, see paragraph 3-47.

Example	*Meaning*
33 CR LF	Enable SRQ on any error or overrange

3-14. G2 (Get Calibration Prompt)

The G2 command is used when calibrating the 8840A under remote control. The command loads the output buffer with a calibration prompt that represents the input expected at the analog inputs. The calibration prompt is formatted as a signed decimal with exponent, as shown in Figure 3-6. The suffix may be enabled with the Y1 command. Example output strings follow.

Examples	*Meaning*
+1.00000E+0 CR LF	Calibration prompt
+190.000E-3 CR LF	Calibration prompt
+1.90000E+0, VDC CR LF	Calibration prompt (Suffix enabled)

If an error has occurred, the G2 command loads the output buffer with an error message instead of the prompt. (See paragraph 3-39 for more about error messages.)

The G2 command is valid only when the calibration mode is enabled by pressing the front panel CAL ENABLE switch. If the 8840A is not in the calibration mode, the G2 command generates an error message.

OUTPUT DATA TYPE	FORMAT	
NUMERIC DATA (from trigger or G2)	±n.nnnnnE±nn[suffix][CR][Lf][EOI]	
	EXAMPLES:	
	+12.3456E+6	Measured value
	+12.3456E+6, OHM	Measured value
	-9.99999E+9	Overrange (≥ 200,000 counts)
	+9.99999E+9,>VDC	Overrange (≥ 200,000 counts)
	+1.0032E+21	Error message
INSTRUMENT CONFIGURATION DATA (From G0, G4, G5, G6, and G7)	nnnn [CR] [LF] [EOI]	
	EXAMPLE:	
	1100	Default G0 value
SRQ MASK DATA (From G1)	nn [CR] [LF] [EOI]	
	EXAMPLE:	
	32	SRQ on any error
USER-DEFINED MESSAGE (From G3)	aaaaaaaaaaaaaaaa [CR] [LF] [EOI]	
	EXAMPLE:	
	FL8840A.01-25-84	

If no messages have ever been stored, a string of 16 nulls (Hex 00) will be returned.

- Numeric data is always in volts, amps, or ohms.
- The terminators CR, LF, and EOI are selected with the Terminator Commands (Wn).
- The suffix, defined below, is enabled with the Y1 command and disabled with the Y0 command. (Default = Y0.)

SUFFIX FORMAT

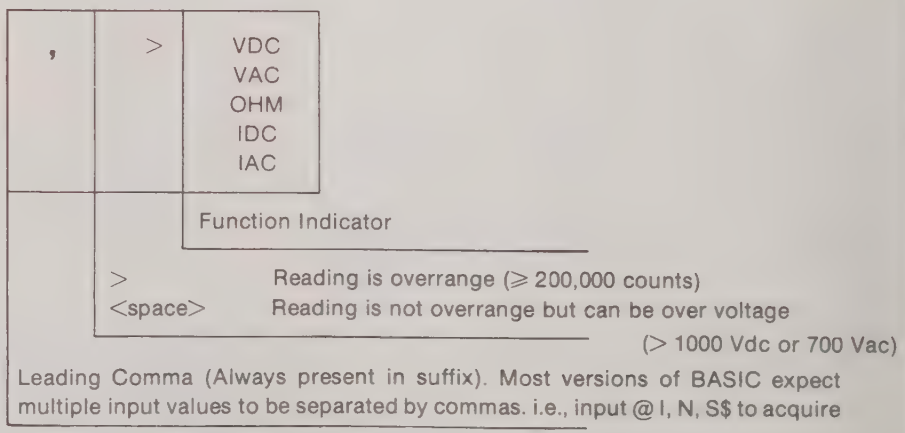

,
>
VDC
VAC
OHM
IDC
IAC
Function Indicator
>
Reading is overrange (≥ 200,000 counts)
<space>
Reading is not overrange but can be over voltage
(> 1000 Vdc or 700 Vac)
Leading Comma (Always present in suffix). Most versions of BASIC expect multiple input values to be separated by commas. i.e., input @ I, N, S$ to acquire the numeric portion and suffix string.

Figure 3-6. Output Data Format

3-15. G3 (Get User-Defined Message)

The G3 command loads the output buffer with the user-defined message stored in calibration memory during the calibration procedure. The message consists of 16 ASCII characters, as shown in Figure 3-6.

The message is stored in calibration memory during calibration using the P3 command. If fewer than 16 characters have been stored, the remaining characters returned are spaces. If no message has ever been stored, a string of 16 null characters (hex 00) will be returned. Some example output strings follow.

Example	*Meaning*
FL8840A.12-17-83 CR LF	Identifies instrument and gives cal date.
01-25-84 CR LF	Gives cal date. The last eight characters are blank.

3-16. G4 (Get Calibration Status)

The G4 command is used when calibrating the 8840A under remote control. The command loads the output buffer with the instrument's calibration status in the format shown in Figure 3-6. The status is represented by a four-digit integer which is interpreted in Table 3-1.

The first two digits are always 1 and 0. The third digit indicates whether or not the calibration verification mode is enabled. (This mode is enabled only when the calibration mode is enabled.) The fourth digit indicates whether or not the calibration mode is enabled, and if so, which part of the calibration procedure the 8840A is in. Example output strings follow.

Example	*Meaning*
1000 CR LF	1: Leading 1
	0: Leading 0
	0: Not in cal verification
	0: Cal mode disabled
1001 CR LF	1: Leading 1
	0: Leading 0
	0: Not in cal verification
	1: Cal mode enabled; A/D cal selected

3-17. G5 (Get IAB Status)

The G5 command loads the output buffer with the IAB status in the format shown in Figure 3-6. As Table 3-1 explains, the IAB status is a four-character string which indicates the status of the FRONT/REAR switch (front or rear analog inputs selected), the autorange feature (autorange on or off), and the OFFSET feature (OFFSET on or off). The first digit is always 1. An example output string follows.

Example	*Meaning*
1011 CR LF	1: Leading 1
	0: FRONT inputs
	1: Autorange off
	1: OFFSET feature on

It is useful to know whether autorange is on or off because this information is not available from the G0 command. For example, the G0 command could indicate that the 8840A was in the 200 mV range, but it would not indicate whether the 8840A was in autorange or manual range.

3-18. G6 (Get YW Status)

The G6 command loads the output buffer with the YW status in the format shown in Figure 3-6. The YW status is a four-character string which indicates which terminators are selected and whether the output suffix is enabled or disabled, as shown in Table 3-1. The first two digits are always 1 and 0. An example output string follows.

Example	*Meaning*
1015 LF CR	1: Leading 1
	0: Leading 0
	1: Y1 (enable output suffix)
	5: W5 (enable LF only)

3-19. G7 (Get Error Status)

The G7 command copies the error status register into the output buffer in the format shown in Figure 3-6. The first two digits are always 1 and 0. The second two digits represent the appropriate error code, if an error has occurred. (Error codes are listed in Table 2-1, Section 2). If an error has not occurred, the second two digits are 00. An example output string follows.

Example	*Meaning*
1071 CR LF	1: Leading 1
	0: Leading 0
	71: Syntax error in device-dependent command string

Table 3-1. Status Data

COMMAND	OUTPUT STRING	MEANING
G0	frst	f = 1 - 6 as in Function commands (Fn) 9 for Self-Test r = 1 - 6 as in Range commands (Rn) s = 0 - 2 as in Reading Rate commands (Sn) t = 0 - 4 as in Trigger Mode commands (Tn)
G1	nn	nn = 00 for SRQ disabled (default) 01 for SRQ on overrange 04 for SRQ on front panel SRQ 08 for SRQ on cal step complete 16 for SRQ on data available 32 for SRQ on any error Note: SRQ mask values may be added for combinations. Example: 33 for SRQ on overrange or any error.
G3	aaaaaaaaaaaaaaaa	16 user-defined ASCII characters
G4	10vm	v = 0 Not in cal verification 1 Cal verification m = 0 Not in calibration mode 1 A/D calibration 2 Offset and gain calibration 4 HF AC calibration
G5	1iab	i = 0 FRONT inputs selected 1 REAR inputs selected a = 0 Autorange on 1 Autorange off (Manual range) b = 0 OFFSET off 1 OFFSET on
G6	10yw	y = 0 output suffix disabled 1 output suffix enabled w = 0 - 7 as in Terminator commands (Wn)
G7	10nn	nn represents error code (See Table 2-1)

The G7 command gives the error status as it exists when the command is executed at its position in the input string. The G7 command does not clear the error status register. For more information about error messages, see paragraph 3-39.

3-20. N (Numeric Entry Command)

Format

N⟨numeric entry⟩ Where ⟨numeric entry⟩ is one of the following:

⟨signed integer⟩

⟨signed real number without exponent⟩

⟨signed real number⟩E⟨signed exponent⟩

Example	*Explanation*
"N12001"	Enters the five-digit integer 12001
"N-1.23E2"	Enters -1.23×10^{2}
"N+154.33E-1"	Enters 1.5433×10^{1}

The N command enters numeric values for use with subsequent Put commands. The interpretation of the numeric value depends on which Put command it is used with.

The E can be used within an N command for entering an exponent of 10. The N can be used without an E, but an E requires a prior N. The exponent can be any integer from -9 to +9.

The mantissa may exceed 5-1/2 digits. The 8840A accurately calculates the appropriate exponent and then disregards all but the first 5-1/2 digits of the mantissa. However, a syntax error will occur if the numeric entry overflows the input buffer.

Example	*Explanation*
"N123456789"	Enters $+1.23456 \times 10^{8}$

3-21. Put Commands

The Put commands P0 through P3 set up the 8840A's configuration and operating modes by entering ("putting") information in the appropriate registers. The put commands are described further in the following paragraphs.

3-22. P0 (Put Instrument Configuration)

Format

N frst P0 Where frst is a four-digit integer interpreted as arguments for the F, R, S, and T commands.

Example	*Explanation*
" N3120 P0"	Identical to F3 R1 S2 T0. Selects 2 WIRE kΩ function, 200Ω range, fast sample rate, continuous trigger.

The P0 command allows broadside loading of the Function, Range, Reading Rate, and Trigger Mode commands (F, R, S, and T). The codes for these commands are listed in Figure 3-5.

A numeric entry for P0 must be within +1000 and +6724. Each of the four digits must not exceed its maximum allowed value (6,7,2, and 4, respectively) or an error message will occur and the instrument configuration will remain unchanged. The entry may be expressed as an integer, real number, or real number with exponent, as described under the N command. Any fractional part is ignored.

Example	*Explanation*
"N3112 P0"	Sets the 8840A to F3, R1, S1, and T2.

3-23. P1 (Put SRQ Mask)

Format

N⟨SRQ mask⟩P1 Where ⟨SRQ mask⟩ is a two-digit integer from 00 to 63.

The P1 command is used to program the 8840A to make service requests on user-specified conditions. The two-digit code for the SRQ mask is interpreted in Table 3-1 under the G1 command. For more about the SRQ mask, see paragraph 3-47.

Numeric entries for the P1 command must be between 0 and +63 (inclusive), or an error will occur and the SRQ mask will remain unchanged. The entry may be expressed as an integer, real number, or real number with exponent, as described under the N command. Any fractional part is ignored.

Example	*Explanation*
"N0.17E+2 P1"	Sets SRQ mask to 17. Enables SRQ on data available or overrange.
"N1 P1"	Sets SRQ mask to 01. (A leading zero is assumed.) Enables SRQ on overrange.

3-24. P2 (Put Calibration Value)

Format

N⟨value⟩P2 Where ⟨value⟩ can be an integer, real number, or real number with exponent, as described under the N command.

Example	*Explanation*
"N1 P2"	If the 8840A is in VDC, the next calibration input expected is 1.00000V dc.

The P2 command is used to enter variable input calibration values just like the front panel VAR IN button. To accept the P2 command, the 8840A must be in the calibration mode (enabled by pressing the front panel CAL ENABLE switch). Otherwise, the P2 command will generate an error message.

The variable input is a measurement value that is to be used as the calibration value for the next calibration step. Its format is the same as a measurement value. But since it is coming from the controller, the value can be specified using any valid format (signed integer, real number, or real number with exponent). For example, if the 8840A prompts for an input value of 100Ω for the next calibration step, but the available source is 98.97Ω, the variable input can be specified as "N+9.897E+1", "N0.9897E2", "N9897E-2", etc. All of these strings result in the same value being used for the next calibration step. For complete information about remote calibration, refer to the Maintenance section.

Numeric values exceeding full scale and negative values for ohms and AC generate error messages.

3-25. P3 (Put User-Defined Message)

Format

P3⟨value⟩ Where ⟨value⟩ is a string of up to 16 ASCII characters.

Example	*Explanation*
"P3FL.8840.12-17-83"	Loads the message "FL.8840.12-17-83" into calibration memory.
"P3HIMOM"	Loads the message "HIMOM" into calibration memory. The remaining eight characters are assumed to be blank.

The P3 command stores a user-defined message in the internal calibration memory during remote calibration. The message may be read with a subsequent G3 command.

The message may consist of up to 16 ASCII characters, and typically represents the instrument's identification, calibration date, calibration facility, etc. If fewer than 16 characters are specified, spaces are appended to fill the message to 16 characters. Spaces and commas in the 16-character input string are suppressed. Lower-case letters are converted to upper-case.

NOTE

If fewer than 16 characters are specified, the P3 command must not be followed by other commands in the same input command string. Otherwise, the subsequent commands will be misinterpreted as part of the 16-character string.

To accept the P3 command, the 8840A must be in the calibration mode (enabled by pressing the front panel CAL ENABLE switch). Otherwise, the P3 command will generate an error message.

3-26. Rn (Range Commands)

The Range commands duplicate the front panel range buttons. For example, R0 selects autorange, and R4 selects the 200V/200 kΩ range.

The R7 command turns autorange off, just as the AUTO button does when it is toggled. Command R7 puts the 8840A into manual range, selecting whatever range the instrument is in when the command is received.

The 8840A defaults to R0 on power-up and any device-clear command (*, DCL, or SDC). The range setting can be read using the G0 command.

3-27. Sn (Reading Rate Commands)

The Reading Rate commands duplicate the front panel RATE button. Like the RATE button, the reading rate command also selects the number of digits displayed and the filter setting. (Filter settings are shown in the specifications in Section 1).

The 8840A defaults to S0 on power-up and any device-clear command (*, DCL, or SDC). The reading rate can be read using the G0 command.

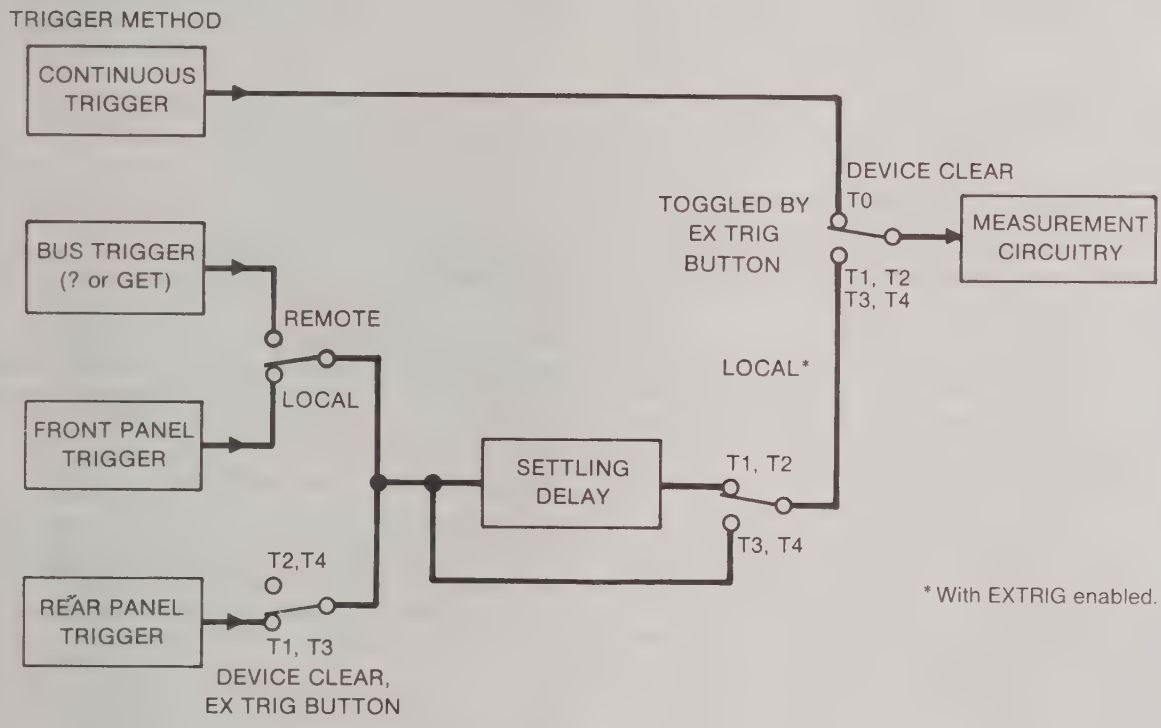
3-28. Tn (Trigger Mode Commands)

The Trigger Mode commands duplicate the front panel EX TRIG button. In addition, the commands can enable or disable the rear panel trigger and the automatic settling time delay.

Figure 3-7 illustrates how to select among the five types of triggers: continuous trigger, front panel trigger, rear panel trigger, and two bus triggers. Note that the front panel TRIG button is enabled only while the instrument is under local control.

In the continuous trigger mode (T0), triggers are initiated at the selected reading rate. Each new reading is loaded into the output buffer as it becomes available, unless the instrument is busy sending previous output data.

The trigger mode can be read using the G0 command. The 8840A defaults to T0 on both power-up and any device-clear command (*, DCL, or SDC).



- Switches represent effect of indicated commands, buttons, and remote/local status.
- Instrument shown in power-up state (T0, local, rear panel trigger enabled).

TRIGGER METHOD	DESCRIPTION
1. Continuous Trigger	Continuous trigger generated by 8840A in internal trigger mode (T0).
2. ? Command	Single trigger initiated by ? command from controller.
3. GET Command	Single trigger initiated by GET command (an interface message) from controller.
4. Front Panel Trigger	Single trigger initiated by front panel TRIG button.
5. Rear Panel Trigger	Single trigger initiated from rear panel EXTTRIG input. (Disabled by T0, T2, T4.)

Figure 3-7. Trigger Selection Logic Diagram

3-29. Wn (Terminator Commands)

The Terminator commands select what terminators the 8840A appends to every output string. The available terminators are: Carriage Return (CR), Line Feed (LF), and End Or Identify (EOI).

CR and LF are ASCII control codes, sent over the data lines just like output data. EOI is a uniline message which is sent simultaneously with the last character in the output string. Normally, each output string is terminated with CR followed by LF and EOI.

The terminator selection can be read using the G6 command. The 8840A defaults to W0 on power-up and any device-clear command.

3-30. X0 (Clear Error Register Command)

The X0 command clears the 8840A's error status register. After an X0 command is executed, a G7 command (Get Error Status) would return 1000 (no errors).

Note that the error status register is also cleared when any device-clear command (*, DCL, or SDC) is executed. However, X0 is useful for clearing the error status register without forcing a complete instrument clear (as do the device-clear commands).

3-31. Yn (Suffix Commands)

The Suffix commands enable or disable a suffix which the 8840A can append to all numeric data (the data in response to G2 or trigger commands). The suffix includes a comma, an overrange indicator (>), and a function indicator (VDC, VAC, OHM, IDC, or IAC). The suffix is illustrated in Figure 3-6. An example of suffixed data is given in paragraph 3-42.

To read suffixed data with a controller using BASIC, one can read the whole line into a string variable and then convert the numeric part into a numeric variable. However, it is much easier to read the numeric part directly into a numeric variable and the suffix into a string variable. The leading comma of the suffic serves as a convenient delimiter. For example, a BASIC program statement might be:

```
INPUT @1,A, B$
```

The suffix status can be read using the G6 command. The 8840A defaults to Y0 on power-up and any device-clear command (*, DCL or SDC), unless in talk-only mode.

3-32. Z0 (Self-Test Command)

The Z0 command initiates the diagnostic self-tests as does pressing the front panel SRQ button for 3 seconds. The 8840A then runs through the tests in sequence. (For a description of the self-tests, see the Maintenance section.)

If the 8840A detects an error, an error message is loaded into the output buffer and displayed on the front panel. After the last test, the 8840A is reset to the power-up configuration, and it begins taking readings.

It is an error to send the 8840A device-dependent commands during the self-tests. However, the controller can still make the 8840A a talker to read the output buffer during the test, and thus record each error that occurrs, except that only the last of the digital self-test errors can be read. After the tests, only the last error is stored in the output buffer if more than one error occured.

Error messages are indicated by an exponent of +21. For more about error messages, see paragraph 3-39.

Since the 8840A is reset at the end of the self-tests, the Z0 command should be the last command in a given command string. The 8840A will ignore any subsequent commands in the same command string.

When the self-tests are complete and no errors have occurred, the serial poll register will have bit 5 (Data Available) true and bit 6 (Any Error) false. See paragraph 3-47 for more about the serial poll register.

3-33. * (Device-Clear Command)

The asterisk command (*) is a device-dependent message which resets the 8840A to the power-up default settings and clears all registers and buffers except for the input buffer. The remote/local status remains unchanged. The asterisk command performs the following:

1. Implements the default settings F1, R0, S0, T0, D0, B0, Y0, W0.
2. Clears the error status register (equivalent to X0).
3. Zeros the SRQ mask, prohibiting service requests (equivalent to N0 P1).
4. Zeros the numeric entry register (equivalent to N0).
5. Zeros the serial poll register.
6. Sets the SRQ line false.

The asterisk command is executed in its proper turn in a string, just like any other command, without affecting the contents of the input buffer. All commands which precede the asterisk command are performed.

The asterisk command is useful to ensure that the 8840A is initialized to the same state each time a program is run. By contrast, the similar interface messages DCL (Device Clear) and SDC (Selected Device Clear) cause the entire input buffer to be cleared immediately.

DCL, SDC, and the asterisk command are all considered to be device-clear commands because the results are so similar; however, DCL and SDC are not identical to the asterisk command described here. DCL and SDC are discussed further in the paragraph on interface messages.

3-34. ? (Single-Trigger Command)

The Single-Trigger command (?) causes the 8840A to take a reading and place the result into the output buffer. To accept this command, the 8840A must be in external trigger mode (selected by the T1, T2, T3, or T4 command).

The Single-Trigger command is one of five ways to trigger a reading. (See Figure 3-7.) Of these, only the Single-Trigger command (?) and the Group Execute Trigger command (GET) are loaded into the input buffer.

3-35. INPUT SYNTAX

The following paragraphs describe how to construct groups of commands for the 8840A. A few definitions are presented first, followed by a description of how the 8840A processes input commands. Guidelines are then summarized in four syntax rules.

3-36. Definitions

- Output commands: Commands which load data into the output buffer. The output commands are: the Get commands (G0 through G7); the Single-Trigger Command (?); the Continuous Trigger command (T0); and Group Execute Trigger (GET), not to be confused with the Get commands.

- Input terminator: An ASCII control code sent by the controller which tells the 8840A to execute all device-dependent commands since the previous terminator. Terminators are CR (Carriage Return), LF (Line Feed), EOI (End Or Identify), and GET (Group Execute Trigger).

- Input command string: One or more device-dependent commands followed by a terminator.

3-37. Input Processing

When the 8840A receives commands from the bus, it stores them in a 31-character input buffer as a continuous string of characters. Commands in the input buffer are not executed or checked for syntax until an input terminator is received or the input buffer becomes full. The only valid input terminators are CR, LF, GET (Group Execute Trigger), and, or EOI.

When the 8840A receives an input terminator, it executes the previous commands in the order in which they were received. As input characters are processed and executed, space is made available in the input buffer for new characters.

If the input buffer becomes full, the 8840A stops accepting characters from the bus until all complete command strings currently in the input buffer have been executed. In this way, characters sent to the 8840A are never lost due to buffer overflow.

In some instances, a terminator is automatically transmitted at the end of the controller's output string. For example, in Fluke BASIC, the PRINT statement always finishes with a CR LF pair. If a controller does not have this feature, the programmer must transmit a terminator explicitly.

The 8840A accepts alphabetic characters in either upper or lower case. Spaces, commas, and control codes are ignored and are not placed in the input buffer. If the 8840A receives a group of terminators (such as CR LF or CR LF EOI), only a single terminator is loaded into the input buffer. Numeric values used in PUT commands may be in NR1, NR2, or NR3 format as described in the IEEE-488 Codes and Formats Recommended Practice. (These correspond to the signed integer, real number, and real-number-with-exponent formats described under the N command.) For reference, Figure 3-8 shows how the 8840A interprets messages.

Illegal commands (e.g., F9) generate an error message, but are otherwise ignored, and do not affect the instrument's configuration.

Example	*Explanation*
"*F9"	This would load the output buffer with an error message and select F1 (established by the * command).

3-38. Syntax Rules

Four syntax rules should be followed when constructing input command strings. They are:

- RULE 1: Read output data only once.

  To prevent old (previously read) data from being read a second time by mistake, the output buffer is always cleared after it has been read. If the output buffer is read twice without an intervening output command, the 8840A will not respond to the second attempt to read the output buffer. (However, if the 8840A is in T0, no intervening command is necessary.)

- RULE 2: Use no more than one output command per input command string.

  Because the 8840A has only one output buffer, it writes new data over old. If an input command string contains more than one output command, only the data from the last command can be read.

DEVICE-DEPENDENT MESSAGES

Single-character Commands

? *	These two commands are complete in themselves (except for string terminator).

Two-character Commands

Bn Cn Dn Fn Gn Pn Rn Sn Wn Xn Yn Zn	Each of these commands requires the single numeric digit (n).

Numeric-entry Characters

N E . + — 0 1 2 3 4 5 6 7 8 9	These characters are used for entering numbers

Terminators

CR	Carriage Return
LF	Line Feed
GET	Group Execute Trigger
EOI	End Or Identify (used as END/DAB)

INTERFACE MESSAGES

Address Messages

MLA	My Listen Address
MTA	My Talk Address
UNL	Unlisten
UNT	Untalk

Universal Commands

ATN	Attention
DCL	Device Clear
IFC	Interface Clear
LLO	Local Lockout
REN	Remote Enable
SPD	Serial Poll Disable
SPE	Serial Poll Enable

Addressed Commands

GET	Group Execute Trigger
GTL	Go To Local
SDC	Selected Device Clear

Ignored Characters

, comma space All other ASCII non-printing characters (except CR and LF)	These characters may be inserted anywhere in a character string without affecting the string. They carry no special meaning and are ignored by the 8840A. They are not placed in the input buffer.

ERROR-PRODUCING CHARACTERS

! " # $ ' ( ) / : < = > ; @ [/] ^ _ ` | ~ H I J K L M O Q U V	The error annunciator is displayed on the 8840A front panel when one of these characters is encountered (ERROR 71).

Figure 3-8. Interpretation of Messages

Example	*Explanation*
"F1 T3 ? F2 ?"	Improper construction. The second trigger writes over the first. To obtain two readings, send two complete command strings (separated by terminators).
"F2 R3 S0 T3 ?"	Correct construction. The string contains only one output command.
"F2 R3 S0"	Correct construction. It is permissible for a string not to contain an output command.

- RULE 3: Read the output data generated by one input command string before sending the next input command string.

Output data remains available in the output buffer until it is read, or until the next input command string is received. As soon as the controller finishes reading the output buffer, or as soon as the 8840A receives a new input terminator, the Data Available bit in the serial poll register is set false. When this bit is false, data can no longer be read from the output buffer. Therefore, an output string which is available must be read by the controller before, rather than after, the next input command string is sent.

Rule 3 is most evident in the external trigger mode, and is best demonstrated by a programming example. The following program is written first incorrectly, and then correctly, in Fluke BASIC using the 1722A Instrument Controller.

Incorrect example

```
100 PRINT @3, "T1 ?"
200 PRINT @3, "F4"
300 INPUT @3, A
```

In this incorrect example, the INPUT statement is located incorrectly for reading the measurement data from line 100. The new input command string "F4" disallows the reading of data from the output buffer.

Correct example

```
100 PRINT @3, "T1 ?"
200 INPUT @3, A
300 PRINT @3, "F4"
```

In this example, the reading taken at line 100 is read at line 200. Then the F4 command is sent. Note that in the external trigger mode, the reading from line 100 flashes on the 8840A display too briefly to see. This is because the function change at line 300 blanks the display until the next trigger.

The previous example could also be correctly programmed as follows:

```
100 PRINT @3, "T1 ? F4"
200 INPUT @3, A
```

- RULE 4: If an input command string contains a trigger, enter the commands in the following order:

  A. Commands to configure the instrument (if any).

  B. The trigger command.

  C. Commands to re-configure the instrument (if any).

  D. Terminator(s).

The principle behind this rule is that the 8840A executes all commands in the exact order they are received, from left to right as written.

Example	*Explanation*
"F3 F4 ?"	Improper construction. F3 is effectively discarded.
"F3 ? F4"	Correct construction. The 8840A is configured in F3, and the trigger is executed. Then the 8840A is left in F4.

3-39. OUTPUT DATA

The following paragraphs describe the data that can be loaded into the 8840A output buffer and sent to the IEEE-488 bus. The paragraphs describe how and when data is loaded into the output buffer, the types of output data, and their relative priority.

Note that the 8840A can also send data to the IEEE-488 bus from the serial poll register. For a description of this data, see paragraph 3-47.

3-40. Loading Output Data

The output buffer is loaded when the 8840A receives an output command, or when an error occurs. Output commands are those device-dependent commands which load the output buffer with data:

- Get commands (G0 through G7)
- Single-trigger command (?)
- Group execute trigger (GET)
- Continuous Trigger (T0)

Because the 8840A gives priority to input processing, it completely processes all characters in the input buffer before it loads the output buffer. When the output buffer is loaded, the Data Available bit in the serial poll register is set true.

Data from the output buffer is not actually loaded onto the IEEE-488 bus until the controller addresses the 8840A as a talker. This is done by sending the interface message MTA (My Talk Address).

3-41. Types of Output Data

The types of data that can be loaded into the output buffer are shown in Figure 3-6. Each type has its own format. Error messages, which are loaded into the output buffer if an error occurs, are formatted as numeric data.

3-42. Numeric Data and Error Messages

Numeric data is loaded into the output buffer in response to the G2 command or an instrument trigger, and has the format shown in Table 3-2. The exponent is always a multiple of 3, as in engineering notation. The position of the decimal point matches the front panel display.

Numeric data is of constant length. It is 11 characters (plus terminaters) when the suffix is disabled, and 16 characters (plus terminaters) when the suffix is enabled.

The suffix is enabled by the Y1 command, and consists of five ASCII characters as shown in Figure 3-6. The suffix is appended only to numeric data, never to status data. The terminators are determined by the Terminator commands. The default is CR LF EOI.

There are three types of numeric data: measurement data, overrange indication, and error messages.

3-43. MEASUREMENT DATA

Measurement data has the numeric data format shown in Table 3-2, and is always in the units of volts, amps, or ohms.

NOTE

In the fast (F) reading rate, the least significant digit is always zero, and should be disregarded when interpreting accuracy specifications.

3-44. OVERRANGE INDICATION

If a reading is overrange ($\geq$ 200,000 counts), the measurement data has the following format:

±9.99999E+9 ⟨suffix⟩ ⟨terminators⟩

Overvoltage readings ($>$ 1000V dc or 700V ac) do not result in this display.

3-45. ERROR MESSAGES

If the 8840A detects an error, it loads an error message into the output buffer in the following numeric format:

+1.00xxE+21 ⟨terminators⟩

The digits xx represent a two-digit error code. (Error codes are listed in Table 2-1, Section 2.) The suffix is always suppressed for error messages.

Example	*Explanation*
+1.0071E+21 CR LF	ERROR 71: Syntax error in device-dependent command string.

As with local operation, none of the errors are latching except for ERROR 31. If the mA DC or mA AC function is requested while the FRONT/REAR switch is in the REAR position, ERROR 31 will persist until the switch is set to FRONT or another function is selected.

Table 3-2. Numeric Output Data Format

RANGE	MEASUREMENT DATA			OVERRANGE INDICATION	ERROR MESSAGES
	VDC, VAC	2-, 4-WIRE kΩ	mA DC, mA AC		
R1	±1xx.xxxE-3	±1xx.xxxE+0	--	±9.99999E+9	+1.00xxE+21
R2	±1.xxxxxE+0	±1.xxxxxE+3	--	↓	↓
R3	±1x.xxxxE+0	±1x.xxxxE+3	--		
R4	±1xx.xxxE+0	±1xx.xxxE+3	--		
R5	±1xxx.xxE+0	±1xxx.xxE+3	±1xxx.xxE-3		
R6	--	±1x.xxxxE+6	--		

To check for an error condition, test whether the output buffer data is greater than or equal to +1E+21, or test the Any Error bit (bit 6) in the serial poll register.

3-46. Status Data

Status data is the output in response to G0, G1, G3, G4, G5, G6, and G7 commands. The data is formatted as shown in Figure 3-6, and is interpreted in Table 3-1. Examples of status data can be found in the description of the Get commands.

The user-defined message loaded by the G3 command consists of 16 characters plus terminators. The SRQ mask loaded by the G1 command consists of two integers plus terminators. All other status data is always a four-digit integer plus terminators. The terminators LF (Line Feed) and CR (Carriage Return) each add an extra character when enabled.

The 8840A begins some status data with a leading ASCII one (1) or a one and a zero (10). This prevents the controller from suppressing any leading zeros present in the 8840A's output string. It also gives a uniform four-character length to all instrument configuration data.

Status data from the Get commands reflects the status of the 8840A at the time the command is executed at its place in the input command string.

3-47. Output Priority

Since only one output string is allowed per input command string, the 8840A gives priority to some types of data over others. An input command string may call for more than one output string. (For example, an input string may contain a Get command but also cause an error message.) However, the output buffer is loaded with only one output string. That string is selected according to the following priority:

1. Status data (from G0, G1, G3, G4, G5, G6, or G7)
2. Error messages (if an error exists)
3. Numeric data (from G2 or a trigger)

This means that an error message always overrides numeric data, but status data is sent even in the presence of an error. However, the status data does not clear the error message; the error message is sent the next time numeric data is requested.

3-48. SERVICE REQUESTS

Service requests let bus instruments get the attention of the system controller. The requests are sent over the SRQ line (one of the IEEE-488 bus lines). If more than one instrument on the bus is capable of sending service requests, the controller can learn which one made the request by taking a serial poll. Each device (including the 8840A) responds to the poll by sending the contents of its serial poll register. The serial poll register indicates whether or not the device requested service, and if so, the reason for the request.

The 8840A may be programmed to make a service request on user-specified conditions. The conditions are specified by entering a value for the service request mask (SRQ mask) with the P1 command. The SRQ mask works by monitoring the serial poll register, which in turn monitors various conditions in the 8840A.

3-49. The Serial Poll Register

The serial poll register is a binary-encoded register which contains eight bits, as illustrated in Figure 3-9. The controller can read the 8840A serial poll register at any time by taking a serial poll. Because serial poll register data is loaded directly onto the bus (instead of being loaded into the output buffer first), reading the serial poll register leaves data in the output buffer intact.

The eight bits of the serial poll register are described in Figure 3-9. Note that the SRQ mask uses bits 1 through 6 to set bit 7 (the RQS bit). When the RQS bit is set true, the 8840A sets the SRQ line true, which generates a service request. A bit is considered true when it is set to 1.

Service requests may also be initiated using the front panel SRQ button if it has been enabled by the SRQ mask.

For example, the serial poll register reads 00010000 (binary) when data is available. This value is read in binary by the controller, which might numerically reformat the value to 16 (decimal) or 10 (hexadecimal).

The serial poll register is cleared whenever the 8840A receives a new input command string.

3-50. The SRQ Mask

The SRQ mask is a two-digit integer that specifies which conditions will generate a service request. The SRQ mask is entered using the P1 command and can be read with the G1 command. The conditions corresponding to each SRQ mask value are listed under G1 in Table 3-1.

The SRQ mask can enable any combination of serial poll register bits 1 through 6. Its six-bit binary representation is ANDed bit-for-bit with serial poll register bits 1 through 6 whenever the output buffer is loaded. If any mask-enabled bit in the serial poll register comes true, the RQS bit (bit 7) is set true, generating a service request.

Example	*Explanation*
"* N4 P1 ?"	An SRQ is generated if the front panel SRQ button is pressed. The string sets

the SRQ mask to 04, which is 000100 in binary. This mask is ANDed with the lower six bits of the serial poll register. The mask thus enables bit 3, the Front Panel SRQ bit.

The SRQ mask codes can be added to select combinations of conditions.

Example	*Explanation*
"* N5 P1 ?"	An SRQ is generated if the SRQ button is pressed or if the trigger results in an overrange reading. The SRQ mask is set to 05, which is 000101 in binary.

At power-up or on any device-clear command, the SRQ mask is set to 00 (decimal). This prevents service requests by holding the RQS bit false under all conditions. For other examples of the SRQ mask, see the description of the P1 command.

3-51. INTERFACE MESSAGES

The interface messages understood by the 8840A can be separated into the three main classes described in the IEEE-488 Standard: address messages (AD), universal commands (UC), and addressed commands (AC). All interface messages described here originate at the controller.

3-52. Address Messages

Address messages are used by the controller to communicate talk and listen control to other devices on the bus. Address messages are sent over the eight data lines of the bus while the controller holds ATN true. Address messages are processed immediately and are not placed in the input buffer. The address messages are:

- MLA My Listen Address -- Addresses a device to listen
- MTA My Talk Address – Addresses a device to talk
- UNL Unlisten -- Addresses all listeners to unlisten
- UNT Untalk -- Addresses all talkers to untalk

3-53. Universal Commands

Universal commands are accepted and interpreted by all devices on the bus. The commands are of two types, multiline messages and uniline messages. Multiline messages are sent over the eight parallel data lines in the IEEE-488 bus. Uniline messages are sent over one of the individual interface management lines in the IEEE-488 bus. All universal commands except DCL are processed immediately by the 8840A, ahead of any device-dependent commands. Only DCL enters the 8840A input buffer.

BIT: 8	7	6	5	4	3	2	1
0	RQS	ANY ERROR	DATA AVAIL-ABLE	CAL STEP COMPLETE	FRONT PANEL SRQ	0	OVER-RANGE
DECIMAL VALUE:	64	32	16	8	4	2	1

Bit	Name	Set	Cleared
1	Overrange	An overrange condition occurs	Device command received, or Bus or Rear Panel Trigger, or Output buffer is read
2	Not used	Never	Always
3	Front panel SRQ	Front panel SRQ button pressed	Device command received
4	Cal Step Complete	Completion of store command (C0)	Device command received
5	Data Available	Output buffer loaded with any data (Readings, Error Messages, Get Responses)	Device command received, or Bus or Rear Panel Trigger, or Output buffer is read
6	Any Error	An error condition occurs. At the same time the output buffer is loaded with an error message. This sets bit 5.	Device command received, or Output buffer is read
7	RQS	Any SRQ mask-enabled bit is set.	All SRQ mask-enabled bits are cleared
8	Not used	Never	Always

Figure 3-9. Serial Poll Register

The 8840A responds to the following universal messages:

ATN Attention -- A uniline message which causes the 8840A to interpret multiline messages as interface messages (AD, AC, or UC). When false, multiline messages are interpreted as device-dependent messages.

IFC Interface Clear -- A uniline message which clears only the interface (not the 8840A) by placing it in a known quiescent state.

REN Remote Enable -- A uniline message which, when received with MLA, switches the 8840A to remote. When REN is set false, the 8840A switches to local and removes local lockout.

DCL Device Clear -- A multiline message which is loaded into the input buffer as a special device-clear command. DCL performs the same operation as the device-dependent command *, except that it is read before any other characters that are already present in the input buffer, and clears the entire input buffer. Processing then continues normally. The action of DCL is not immediate; if the 8840A is taking a reading when DCL is received, the DCL command is executed after the measurement is finished.

LLO Local Lockout -- A multiline message which disables the front panel LOCAL button. The result is that the local mode is not accessible by front panel control.

SPD Serial Poll Disable -- A multiline message which removes the serial poll enable state.

SPE Serial Poll Enable -- A multiline message which causes the serial poll data (rather than output buffer data) to be transferred on the bus once ATN becomes false.

3-54. Addressed Commands

Addressed commands are multiline messages which are accepted and interpreted by only those devices currently addressed to listen. The 8840A responds to the following addressed commands:

GET Group Execute Trigger -- (Not to be confused with the device-dependent Get commands.) GET loads a trigger command into the input buffer and also terminates the string at that point. Only a single character is loaded into the input buffer. The trigger command is executed in its proper turn in the input string, rather than immediately. When executed, GET initiates a measurement.

GTL Go To Local -- Causes the 8840A to switch to local. This command does not enter the input buffer. If the display has been blanked (with a D1 command), issue a D0 command before sending GTL.

SDC Selected Device Clear -- Identical to the universal command DCL, but is accepted and interpreted by current listeners only. Therefore, it clears the 8840A only if it is addressed to listen.

3-55. TALK-ONLY MODE

The talk-only mode lets you take advantage of the remote capability of the 8840A without having to use an instrument controller. To put the 8840A in the talk-only mode:

1. Turn the 8840A POWER switch OFF.
2. Set the rear panel TALK ONLY bit switch to 1 (the up position).
3. Connect the 8840A via the IEEE-488 bus to your printer, data logger, or other device.
4. Configure the other device as a listener only.
5. Turn the 8840A POWER switch ON.
6. Configure the 8840A with the front panel controls.

The 8840A reads the TALK ONLY bit switch on power-up and when it receives the interface command IFC. You can therefore set the TALK ONLY switch to 1 after power-up as long as you then send the 8840A the IFC command.

3-56. REMOTE CALIBRATION

The 8840A can be calibrated over the 8840A bus using remote commands. Refer to the Maintenance section for details.

3-57. TIMING CONSIDERATIONS

To help you take the best advantage of the speed of the 8840A, external trigger timing for the IEEE-488 Interface is described in the specifications in Section 1.

3-58. IMMEDIATE MODE COMMANDS

Many controllers have some amount of "immediate

mode" capability. That is, commands may be given interactively to the 8840A via the run-time-system without the need for actually running a program. The controller accepts and executes these commands one at a time. Some commonly used commands are listed in Table 3-3 for several controllers. These are provided for the convenience of instrument demonstrations, set-up and check-out, and for those with limited experience with IEEE-488 bus operations.

As a general note: The entire 8840A command set should work well provided the "port clear" and "device clear" commands are given first. You should then be able to send any other commands in the 8840A command set without repeating the clearing commands.

3-59. EXAMPLE PROGRAMS

Several example programs for the 8840A using various controllers are presented in the remaining figures in this section. In all of these examples, the 8840A is set to IEEE-488 address 4 (rear panel switch setting 000100). Of course, any other address (00 to 30) could be substituted.

In each of these examples, the instrument is cleared prior to configuration set-ups. This ensures that the 8840A configuration has been completely defined.

To run these programs, it is not necessary to type in all the comments (which appear to the right of the exclamation marks). Also, spaces are placed between commands for ease of reading; they are not required.

NOTE

For the examples using the Fluke 1720A or 1722A, the 8840A is plugged into port 0. The port is initialized by the INIT statement, which sends IFC (interface clear).

Table 3-3. Immediate-Mode Commands for Various Controllers

FUNCTION PERFORMED	FLUKE-BASIC on 1720A or 1722A	HP-HPL on HP9825 Calculator	HP-BASIC on HP9816-PC and HP-85 Calculator	TEK-BASIC on 4051 Graphics System
INITIALIZE Port	INIT PORT 0	cli 7	CLEAR 7	INIT
CLEAR Instrument	CLEAR @4	clr 704	CLEAR 704	PRINT @4:"*"
REMOTE Commands	REMOTE @4	rem 704	REMOTE 704	WBYTE @36,17:
LOCAL Control	LOCAL @4	lcl 704	LOCAL 704	WBYTE @36,1:
EXTERNAL TRIGGER	PRINT @4,"T1"	wrt 704,"T1"	OUTPUT 704;"T1"	PRINT @4:"T1"
TRIGGER Instrument	TRIG @4	trg 704	TRIGGER 704	PRINT @4:"?"
GET Output Data	INPUT @4,A	red 704, A	ENTER 704;A (Note 2)	INPUT @4:A
PRINT Data to Screen	PRINT A	prt A	PRINT A (Note 2)	PRINT A
CONFIGURE for VAC	PRINT @4,"F2"	wrt 704,"F2"	OUTPUT 704;"F2"	PRINT @4:"F2"
CONFIGURE for 200Vac	PRINT @4,"R4"	wrt 704,"R4"	OUTPUT 704;"R4"	PRINT @4:"R4"
TRIGGER Continuously	PRINT @4,"T0"	wrt 704,"T0"	OUTPUT 704;"T0"	PRINT @4:"T0"
SUFFIXES Enable	PRINT @4,"Y1"	wrt 704,"Y1"	OUTPUT 704;"Y1"	PRINT @4:"Y1"
GET Data & Suffix	INPUT @4, A,A$	red 704,A,A$ (Note 1)	ENTER 704;A,A$ (Note 2)	INPUT %4:A,A$
PRINT Data & Suffix	PRINT A,A$	prt A$,A	PRINT A,A$ (Note 2)	PRINT A,A$

Notes:

1. Before using A$ on the 9825 is necessary to enter "dim A$[6]" to allocate a string variable. This statement allows six characters.

2. In the HP9816 system, variables cannot be created from the keyboard; they must be created by running a program. (See error 910 for that system.) To get around this, type in a very short program as follows:

```
SCRATCH        (Hit "EXEC" key)
10 A = 0       (Hit "ENTER" key)
20 A$ = ""     (Hit "ENTER" key)
30 END         (Hit "ENTER" key)
(Hit "RUN" key)
```

This program creates the variables 'A' and 'A$' so that they may be accessed in immediate mode and changed at will. This program is not necessary for the HP-85 Calculator.

```
1!  This program selects VDC (F1), Autorange(R0), Slow rate(S0), continuous
2!  trigger(T0), Suffixes enabled (Y1). The program takes 10 readings and
3!  stops. The 8840A is addressed to port 0 device #4 under control of a
4!  Fluke 1720A or 1722A Instrument Controller. In the INPUT statement, the
5!  controller assigns the first part of the 8840A output response (the
6!  measurement value) to R, and assigns the second part (the suffix) to R$.
7!
18!==================FLUKE-BASIC on 1720A, 1722A================================
19!
20   INIT PORT 0                                        !Clear port
25   CLEAR PORT 0                                       !Clear instr to default functions
35   PRINT @4, "F1 R0 S0 T0 Y1"                         !Write functions to instrument
40     FOR I = 1 TO 10
45        INPUT @4,R,R$                                 !Get data from 8840A
50        PRINT "     ",I,R,R$                          !Print to 1722 display
55     NEXT I
60   END



17!        EQUIVALENT PROGRAM FOR HP9816 PC AND HP-85 CALCULATOR IN HP-BASIC
18!=============================================================================
19!
20   CLEAR 7                                            !Clear port
25   CLEAR 704                                          !Clear instr to default functions
35   OUTPUT 704;   "F1 R0 S0 T0 Y1"                     !Write functions to instrument
40     FOR I = 1 TO 10
45        ENTER 704; R,R$                               !Get data from 8840A
50        PRINT "     ",I,R,R$                          !Print to HP9816 display
50        PRINT I;R;R$                  !Substitute this PRINT statement for HP-85
55     NEXT I
60   END



!                  EQUIVALENT PROGRAM FOR HP9825 CALCULATOR
!=============================================================================
!
 0:  dim R$[6]                                         !Allocate string variable up to 6 characters
 1:  fxd 5                                             !Set display to 5 decimal places
 2:  cli 7                                             !Clear port
 3:  clr 704                                           !Clear instr to default functions
 4:  10 -) I                                           !Initialize reading counter
 5:  wrt 704,   "F1 R0 S0 T0 Y1"                       !Write functions to instrument
 6:  "IN":  I-1 -) I                                   !Decrement reading counter
 7:         red 704,  R,R$                             !Get data from 8840A
 8:         prt R$,R                                   !Print to HP9825 printer
 9:   if I<>0;   gto "IN"
10:  end



17REM  EQUIVALENT PROGRAM FOR TEKTRONIX 4051 SERIES GRAPHICS SYSTEM IN TEK-BASIC
18REM=============================================================================
19REM
20   INIT                                               REM Clear port
35   PRINT @4: "F1 R0 S0 T0 Y1"                         REM Write functions to instrument
40     FOR I = 1 TO 10
45        INPUT %4:R,R$                                 REM Get data from 8840A
50        PRINT "     ",I,R,R$                          REM Print to 1722 display
55     NEXT I
60   END
```

Figure 3-10. Example Program: Taking 10 Readings

```
1! This is a sample program which commands the 8840A to the default state of
2! VDC, autorange, slow rate, continuous trigger.  All readings appear simul-
3! taneously on the instrument display while being logged on the controller
4! display with suffixes enabled for function readout. Full local control is
5! given to the 8840A so that any range or function may invoked easily. The
6! controller always echos the 8840A display while this program is running.
7! The first copy of this program runs on Fluke 1720A and 1722A Controllers.
8! The second runs on the HP9816 personal computer running HP-BASIC. The third
9! runs on the HP9825 (HPL) calculator.
10!
11!==============FLUKE BASIC on 1720A,1722A==================================
12!
20!================================INITIALIZATION
30 INIT PORT 0                          !Clear port
40 CLEAR PORT 0                        !Clear Instrument
50 WAIT 1000                           !Wait 1 second before sending command
60 PRINT @4,"F1 R0 S0 TO Y1"           !F1=VAC, R0=autorange, S0=slow rate
70!                                    !T0=continuous trigger, Y1=enable suffix
80 X=0
90 LOCAL @4                            !Give local control to instrument
95!
100!===============================MAIN
110 INPUT @4,A,A$                        !Get reading and suffix
120   X=X+1                              !Increment reading count
130   PRINT "              ",X,A,A$      !Display readings incl suffix
140 GOTO 110
145!
200 END


11!      EQUIVALENT PROGRAM FOR HP9816 PC AND HP-85 CALCULATOR IN HP-BASIC
12!=========================================================================

20!================================INITIALIZATION
30 CLEAR 7                             !Clear HPIB port
40 CLEAR 704                           !Clear instrument
60 OUTPUT 704;"F1 R0 S0 TO Y1"         !F1=VAC, R0=autorange, S0=slow rate
70!                                    !T0=continuous trigger, Y1=enable suffix
80 X=0
90 LOCAL 704                           !Give local control to instrument
95!
100!===============================MAIN
110 ENTER 704;A,A$                       !Get reading and suffix
120   X=X+1                              !Increment reading count
130   PRINT "              ",X,A,A$      !Display readings incl suffix (Use for HP9816
130   DISP  X;A;A$     !For HP-85, substitute this line for PRINT statement above
140 GOTO 110
145!
200 END


!              EQUIVALENT PROGRAM FOR HP9825 CALCULATOR
!=======================================================================

!================================INITIALIZATION
 0: dim A$[6]                          !Allocate string variable up to 6 characters
 1: fxd 5                              !Set display to 5 decimal places
 2: cli 7                              !Clear HPIB port
 3: clr 704                            !Clear instrument
 4: wait 1000
 5: wrt 704, "F1 R0 S0 TO Y1"          !F1=VAC, R0=autorange, S0=slow rate
!                                      !T0=continuous trigger, Y1=enable suffix
 6: 0 -> X
 7: lcl 704                            !Give local control to instrument

!===============================MAIN
 8: "IN": red 704,A,A$                 !Get reading and suffix
 9: X+1 -> X                           !Increment reading count
10: dsp X,A,A$                         !Display readings incl suffix
11: gto "IN"

12: end


10REM  EQUIVALENT PROGRAM FOR TEKTRONIX 4051 SERIES GRAPHICS SYSTEM IN TEK-BASIC
11REM=========================================================================
12REM
20REM================================INITIALIZATION
30 INIT                                REM Clear port
60 PRINT @4: "F1 R0 S0 TO Y1"          REM F1=VAC, R0=autorange, S0=slow rate
70REM                                  REM T0=continuous trigger, Y1=enable suffix
80 X=0
90 WBYTE @36,1:                        REM Give local control to instrument
95REM
100REM===============================MAIN
110 INPUT %4:A,A$                        REM Get reading and suffix
120   X=X+1                              REM Increment reading count
130   PRINT "              ",X,A,A$      REM Display readings incl suffix
140 GOTO 110
145REM
200 END
```

Figure 3-11. Example Program: Taking Readings with Local Control

```
1! The following program illustrates one possible use of the serial poll
2! register.  In this case it is merely looking for data available.  The in-
3! strument is addressed to port 0 device #4 under control of a FLUKE
4! 1720A or 1722A controller. The function of the program is to display on the
5! 1720A screen the lowest resistance seen across the input terminals of the
6! 8840A using the 2-wire ohms function in autorange.  See function list for
7! interpretation of line 110.
8!
98!==============FLUKE BASIC on 1720A or 1722A==============================
99!
100 INIT PORT 0  \  CLEAR PORT 0  \  WAIT 500  !Clear port,clear inst, delay
110 PRINT @4, "N3001P0 Y1 ?"                   !Instr functions + trigger
120 INPUT @4,A,A$                              !Get first reading
130 PRINT "     ",A,A$;"S (2-wire) LOWEST READING"
140 TRIG @4
160 B%=SPL(4)                                  !get Serial Poll Reg @ addr #1
170  IF (B%=0%)    THEN 160                    !Looking for data available
175    INPUT @4,R,A$                           !Get next data
180  IF R)=A  THEN 140                         !Throw away data if not lowest
185    A=R                                     !Update lowest reading
190    GOTO 130                                !Print new low
900 END

97!       EQUIVALENT PROGRAM FOR HP9816 PC AND HP-85 CALCULATOR IN HP-BASIC
98!=============================================================================
99!
100 CLEAR 7                                    !Clear HPIB port
101 CLEAR 704                                  !Clear 8840A
110 OUTPUT 704; "N3001P0 Y1 ?"                 !Instr functions + trigger
120 ENTER 704; A,A$                            !Get first reading
130 PRINT "     ",A,A$;"S (2-wire) LOWEST READING"    !Use this line for HP9816
130 DISP A;A$;"S LOWEST READ" !For HP-85, substitute this for PRINT statement above
140 TRIGGER 704
160 B=SPOLL(704)                               !get Serial Poll Reg @ addr #1
170  IF (B=0)   THEN 160                      !Looking for data available
175    ENTER 704;R,A$                          !Get next data
180  IF R)=A  THEN 140                         !Throw away data if not lowest
185    A=R                                     !Udata lowest reading
190    GOTO 130                                !Print new low
900 END

!              EQUIVALENT PROGRAM FOR HP9825 CALCULATOR
!=============================================================================
!
 0: dim A$[6]                                  !Allocate string variable up to 6
                                               characters
 1: fxd 3                                      !Fix 3 decimal places
 2: cli 7                                      !Clear HPIB port
 3: clr 704                                    !clear inst
 4: wrt 704, "N3001P0 Y1 ?"                    !Instr functions + trigger
 5: red 704, A,A$                              !Get first reading
 6: "DISP": dsp A,A$,"-2w LOWEST READ"
 7: "TRIG": trg 704
 8: "POLL": rds (704) -) X                     !get Serial Poll Reg @ addr #1
 9:  if (B=0);  gto "POLL"                     !Looking for data available
10:    red 704,R,A$                           !Get next data
11:  if R)=A;  gto "TRIG"                     !Throw away data if not lowest
12:    R -) A;   gto "DISP"                   !Udata lowest reading
13: END


97REM  EQUIVALENT PROGRAM FOR TEKTRONIX 4051 SERIES GRAPHICS SYSTEM IN TEK-BASIC
98REM=============================================================================
99REM
100 INIT                                       REM Clear port
110 PRINT @4: "N3001P0 Y1 ?"                   REM Instr functions + trigger
120 INPUT %4:A,A$                              REM Get first reading
130 PRINT "     ",A,A$;"S (2-wire) LOWEST READING"
140 PRINT @4: "?"                              REM Trigger reading
160 WBYTE @95,24:                              REM Turn on serial-poll-enable
165 WBYTE @68:                                 REM At address #4
167 RBYTE B                                    REM Get serial poll register
168 WBYTE @95,25:                              REM Turn off serial-poll-enable
170  IF (B=0)    THEN 160                      REM Looking for data available
175    INPUT %4:R,A$                           REM Get next data
180  IF R)=A  THEN 140                         REM Throw away data if not lowest
185    A=R                                     REM Update lowest reading
190    GOTO 130                                REM Print new low
900 END
```

Figure 3-12. Example Program: Using the Serial Poll Register

```
1! The following program illustrates one possible use of the serial poll
2! register.  In this case it is merely looking for data available.  The in-
3! strument is addressed to port 0 device #4 under control of a FLUKE 1720A
4! 1720A or 1722A controller. The function of the program is to display on the
5! 1720A screen the lowest resistance seen across the input terminals of the
6! 8840A using the 2-wire ohms function in autorange.  See function list for
7! interpretation of line 110.
8!
98!===============FLUKE BASIC on 1720A or 1722A==============================
99!
100 INIT PORT 0  \  CLEAR PORT 0  \  WAIT 500  !Clear port,clear inst, delay
110 PRINT @4, "N3001P0 Y1 ?"                   !Instr functions + trigger
120 INPUT @4,A,A$                              !Get first reading
130 PRINT "      ",A,A$;"S (2-wire) LOWEST READING"
140 TRIG @4
160 B%=SPL(4)                                  !get Serial Poll Reg @ addr #1
170  IF (B%=0%)    THEN 160                    !Looking for data available
175    INPUT @4,R,A$                           !Get next data
180  IF R)=A  THEN 140                         !Throw away data if not lowest
185    A=R                                     !Update lowest reading
190    GOTO 130                                !Print new low
900 END

97!       EQUIVALENT PROGRAM FOR HP9816 PC AND HP-85 CALCULATOR IN HP-BASIC
98!=============================================================================
99!
100 CLEAR 7                                    !Clear HPIB port
101 CLEAR 704                                  !Clear 8840A
110 OUTPUT 704; "N3001P0 Y1 ?"                 !Instr functions + trigger
120 ENTER 704; A,A$                            !Get first reading
130 PRINT "      ",A,A$;"S (2-wire) LOWEST READING"     !Use this line for HP9816
130 DISP A;A$;"S LOWEST READ"     !For HP-85, substitute this for PRINT statement above
140 TRIGGER 704
160 B=SPOLL(704)                               !get Serial Poll Reg @ addr #1
170  IF (B=0)    THEN 160                      !Looking for data available
175    ENTER 704;R,A$                          !Get next data
180  IF R)=A  THEN 140                         !Throw away data if not lowest
185    A=R                                     !Udata lowest reading
190    GOTO 130                                !Print new low
900 END



!              EQUIVALENT PROGRAM FOR HP9825 CALCULATOR
!=============================================================================
!
 0: dim A$[6]                                  !Allocate string variable up to 6 characters
 1: fxd 3                                      !Fix 3 decimal places
 2: cli 7                                      !Clear HPIB port
 3: clr 704                                    !clear inst
 4: wrt 704, "N3001P0 Y1 ?"                    !Instr functions + trigger
 5: red 704, A,A$                              !Get first reading
 6: "DISP": dsp A,A$,"-2w LOWEST READ"
 7: "TRIG": trg 704
 8: "POLL": rds (704) -) X                     !get Serial Poll Reg @ addr #1
 9:  if (B=0);  gto "POLL"                     !Looking for data available
10:    red 704,R,A$                           !Get next data
11:  if R)=A;  gto "TRIG"                     !Throw away data if not lowest
12:    R -) A;   gto "DISP"                   !Udata lowest reading
13: END


97REM  EQUIVALENT PROGRAM FOR TEKTRONIX 4051 SERIES GRAPHICS SYSTEM IN TEK-BASIC
98REM=============================================================================
99REM
100 INIT                                       REM Clear port
110 PRINT @4: "N3001P0 Y1 ?"                   REM Instr functions + trigger
120 INPUT %4:A,A$                              REM Get first reading
130 PRINT "      ",A,A$;"S (2-wire) LOWEST READING"
140 PRINT @4: "?"                              REM Trigger reading
160 WBYTE @95,24:                              REM Turn on serial-poll-enable
165 WBYTE @68:                                 REM At address #4
167 RBYTE B                                    REM Get serial poll register
168 WBYTE @95,25:                              REM Turn off serial-poll-enable
170  IF (B=0)    THEN 160                      REM Looking for data available
175    INPUT %4:R,A$                           REM Get next data
180  IF R)=A  THEN 140                         REM Throw away data if not lowest
185    A=R                                     REM Update lowest reading
190    GOTO 130                                REM Print new low
900 END
```

Figure 3-13. Example Program: Interrupt Processing

```
!              EQUIVALENT PROGRAM FOR HP9825 CALCULATOR
!=================================================================

!======================INITIALIZE=================================
  0: dim A$[6]                    !Allocate string variable up to 6 characters
  1: flt 5                        !Set display to 5 places
  2: cli 7                        !Clear HPIB port
  3: clr 704                      !Clear instrument
  4: wrt 704, "N4P1 Y1"
  5: lcl 704
  6: oni 7, "SRQ"                 !Direct interrupts on chan 7 to instr 500
  7: eir  7                       !Enable interrupts on HPIB (SRQ)

!======================MAIN=======================================
  8:"HERE":  gto  "HERE"          !Simulated Controller activity with other matters

!======================SERIAL POLL================================
  9:"SRQ": rds (704) -) X         !This code is looking for the interrupting device.
 10:     if X( )0; gto "DVM"      !Since there is only one device of interest, lines
!   rds (705) -) X                !530 and 540 are commented out but illustrated one
!       if X( )0; gto "CAL"       !possible way to implement

!======================INTERRUPT ROUTINE FOR 8840A================
 11:"DVM": red 704, A, A$         !Get data from 8840A
 12:       prt A$, A              !Print data to HP9825
 13: eir 7                        !Re-enable interrupts on HPIB
 14: iret

 15: end
```

```
98REM EQUIVALENT PROGRAM FOR TEKTRONIX 4051 SERIES GRAPHICS SYSTEM IN TEK-BASIC
99REM=============================INITIALIZE=====================================
100REM============================INITIALIZE=====================================
110 INIT                                  REM Clear port
120 PRINT @4: "N4P1 Y1"                   REM SRQ mask (interrupt only on SRQ)
130 WBYTE @36,1:                          REM Set instrument to LOCAL control
140 ON SRQ THEN 500

400REM=============================MAIN===========================================
410 GOTO 410              REM This is, of course, a locked loop but it represents
420REM                    REM an arbitrary amount of time when the controller
430REM                    REM can be doing other things while waiting for readings
440REM                    REM from port 0 on an INTERRUPT basis.

500REM=============================SERIAL POLL====================================
510 POLL P1,P2;4;5;6                      REM This statement is generalized to
520 GOTO P1 OF 600,700,800                REM include devices 4, 5, 6 but of course
530REM                                    REM 5 and 6 do not exist in this example.
540REM                                    REM Parallel poll is particularly
550REM                                    REM convenient in this controller.

600REM============================INTERRUPT ROUTINE for 8840A====================
610 INPUT %4:A,A$                         REM Get data.
620 PRINT "    ",A,A$                     REM Print to 4051 screen.
630 RETURN                                REM Resume previous task. Return
640REM                                    REM address is memorized automatically
650REM                                    REM just like the "ON ERROR" mechanism
660REM                                    REM in BASIC (in this case line 410).

900 END
```

Figure 3-13. Example Program: Interrupt Processing (cont)

```
10   !Program to record errors during selftest.
20   !
30   !There are some items to take note of.
40   !     1. If more than one digital test error occurs, then only the
50   !        last one will be reported.
60   !     2. The response to a G0 command during selftest is "9XXX".
70   !     3. The response to a G7 command with no errors present is
80   !        "1000".
90   !
100  DA%=1%                              !8840 on 1720 port 0, address 1
110  TIMEOUT 10000                       !10 second timeout
120  PRINT
130  PRINT "MONITORING SELFTEST"
140  INIT PORT 0                         !initialize port, set ren
150  CLEAR @DA%                          !clear 8840
160  PRINT @DA%,'Z0'                     !start selftest
170  !
180  PRINT @DA%,G7' \ INPUT @DA%,E$
190  IF (E$ = "1000") THEN 220
200  PRINT @AD%,'X0'
210  PRINT "ERROR ";RIGHT(E$,3);" OCCURED" !print analog errors
220  PRINT @DA%,'G0' \ INPUT @DA%,ST$
230  IF (ST$ )= "9000") GOTO 180
240  PRINT @DA%,'G7' \ INPUT @DA%,E$
250  IF (E$ = "1000") THEN 270
260  PRINT "ERROR ";RIGHT(E$,3);" OCCURED" !print last digital error
270  PRINT
280  PRINT "SELFTEST DONE"
290  STOP
300  END
```

Figure 3-14. Example Program: Record Errors During Selftest

Table 3-4. ASCII/IEEE Std 488-1978 Bus Codes

ASCII CHAR.	DECIMAL	OCTAL	HEX	BINARY 7654 3210	DEV. NO.	MESSAGE ATN TRUE	
NUL	0	000	00	0000 0000			ADDRESSED COMMANDS
SOH	1	001	01	0000 0001		GTL	
STX	2	002	02	0000 0010			
ETX	3	003	03	0000 0011			
EOT	4	004	04	0000 0100		SDC	
ENQ	5	005	05	0000 0101		PPC	
ACK	6	006	06	0000 0110			
BELL	7	007	07	0000 0111			
BS	8	010	08	0000 1000		GET	
HT	9	011	09	0000 1001		TCT	
LF	10	012	0A	0000 1010			
VT	11	013	0B	0000 1011			
FF	12	014	0C	0000 1100			
CR	13	015	0D	0000 1101			
SØ	14	016	0E	0000 1110			
SI	15	017	0F	0000 1111			
DLE	16	020	10	0001 0000			UNIVERSAL COMMANDS
DC1	17	021	11	0001 0001		LLO	
DC2	18	022	12	0001 0010			
DC3	19	023	13	0001 0011			
DC4	20	024	14	0001 0100		DCL	
NAK	21	025	15	0001 0101		PPU	
SYN	22	026	16	0001 0110			
ETB	23	027	17	0001 0111			
CAN	24	030	18	0001 1000		SPE	
EM	25	031	19	0001 1001		SPD	
SUB	26	032	1A	0001 1010			
ESC	27	033	1B	0001 1011			
FS	28	034	1C	0001 1100			
GS	29	035	1D	0001 1101			
RS	30	036	1E	0001 1110			
US	31	037	1F	0001 1111			
SPACE	32	040	20	0010 0000	0	MLA	LISTEN ADDRESSES
!	33	041	21	0010 0001	1	MLA	
"	34	042	22	0010 0010	2	MLA	
#	35	043	23	0010 0011	3	MLA	
$	36	044	24	0010 0100	4	MLA	
%	37	045	25	0010 0101	5	MLA	
&	38	046	26	0010 0110	6	MLA	
'	39	047	27	0010 0111	7	MLA	
(	40	050	28	0010 1000	8	MLA	
)	41	051	29	0010 1001	9	MLA	
*	42	052	2A	0010 1010	10	MLA	
+	43	053	2B	0010 1011	11	MLA	
,	44	054	2C	0010 1100	12	MLA	
-	45	055	2D	0010 1101	13	MLA	
.	46	056	2E	0010 1110	14	MLA	
/	47	057	2F	0010 1111	15	MLA	
0	48	060	30	0011 0000	16	MLA	
1	49	061	31	0011 0001	17	MLA	
2	50	062	32	0011 0010	18	MLA	
3	51	063	33	0011 0011	19	MLA	
4	52	064	34	0011 0100	20	MLA	
5	53	065	35	0011 0101	21	MLA	
6	54	066	36	0011 0110	22	MLA	
7	55	067	37	0011 0111	23	MLA	
8	56	070	38	0011 1000	24	MLA	
9	57	071	39	0011 1001	25	MLA	
:	58	072	3A	0011 1010	26	MLA	
;	59	073	3B	0011 1011	27	MLA	
<	60	074	3C	0011 1100	28	MLA	
=	61	075	3D	0011 1101	29	MLA	
>	62	076	3E	0011 1110	30	MLA	
?	63	077	3F	0011 1111		UNL	

ASCII CHAR.	DECIMAL	OCTAL	HEX	BINARY 7654 3210	DEV. NO.	MESSAGE ATN TRUE	
@	64	100	40	0100 0000	0	MTA	TALK ADDRESSES
A	65	101	41	0100 0001	1	MTA	
B	66	102	42	0100 0010	2	MTA	
C	67	103	43	0100 0011	3	MTA	
D	68	104	44	0100 0100	4	MTA	
E	69	105	45	0100 0101	5	MTA	
F	70	106	46	0100 0110	6	MTA	
G	71	107	47	0100 0111	7	MTA	
H	72	110	48	0100 1000	8	MTA	
I	73	111	49	0100 1001	9	MTA	
J	74	112	4A	0100 1010	10	MTA	
K	75	113	4B	0100 1011	11	MTA	
L	76	114	4C	0100 1100	12	MTA	
M	77	115	4D	0100 1101	13	MTA	
N	78	116	4E	0100 1110	14	MTA	
O	79	117	4F	0100 1111	15	MTA	
P	80	120	50	0101 0000	16	MTA	
Q	81	121	51	0101 0001	17	MTA	
R	82	122	52	0101 0010	18	MTA	
S	83	123	53	0101 0011	19	MTA	
T	84	124	54	0101 0100	20	MTA	
U	85	125	55	0101 0101	21	MTA	
V	86	126	56	0101 0110	22	MTA	
W	87	127	57	0101 0111	23	MTA	
X	88	130	58	0101 1000	24	MTA	
Y	89	131	59	0101 1001	25	MTA	
Z	90	132	5A	0101 1010	26	MTA	
[	91	133	5B	0101 1011	27	MTA	
\	92	134	5C	0101 1100	28	MTA	
]	93	135	5D	0101 1101	29	MTA	
^	94	136	5E	0101 1110	30	MTA	
_	95	137	5F	0101 1111		UNT	
`	96	140	60	0110 0000	0	MSA	SECONDARY ADDRESSES
a	97	141	61	0110 0001	1	MSA	
b	98	142	62	0110 0010	2	MSA	
c	99	143	63	0110 0011	3	MSA	
d	100	144	64	0110 0100	4	MSA	
e	101	145	65	0110 0101	5	MSA	
f	102	146	66	0110 0110	6	MSA	
g	103	147	67	0110 0111	7	MSA	
h	104	150	68	0110 1000	8	MSA	
i	105	151	69	0110 1001	9	MSA	
j	106	152	6A	0110 1010	10	MSA	
k	107	153	6B	0110 1011	11	MSA	
l	108	154	6C	0110 1100	12	MSA	
m	109	155	6D	0110 1101	13	MSA	
n	110	156	6E	0110 1110	14	MSA	
o	111	157	6F	0110 1111	15	MSA	
p	112	160	70	0111 0000	16	MSA	
q	113	161	71	0111 0001	17	MSA	
r	114	162	72	0111 0010	18	MSA	
s	115	163	73	0111 0011	19	MSA	
t	116	164	74	0111 0100	20	MSA	
u	117	165	75	0111 0101	21	MSA	
v	118	166	76	0111 0110	22	MSA	
w	119	167	77	0111 0111	23	MSA	
x	120	170	78	0111 1000	24	MSA	
y	121	171	79	0111 1001	25	MSA	
z	122	172	7A	0111 1010	26	MSA	
{	123	173	7B	0111 1011	27	MSA	
|	124	174	7C	0111 1100	28	MSA	
}	125	175	7D	0111 1101	29	MSA	
~	126	176	7E	0111 1110	30	MSA	
DEL	127	177	7F	0111 1111			

Section 4
Measurement Tutorial

4-1. INTRODUCTION

This section discusses considerations and techniques to help you use the 8840A effectively. Among other things, this section discusses sources of error which are an inherent part of the measurement process and which occur for all multimeters. By understanding why and when these errors occur, and by knowing how and when to correct for them, you can make accurate measurements with confidence.

This section also discusses the relative benefits of 2-wire and 4-wire ohms, describes special considerations for making ac measurements, and presents some unusual applications--for example, using the test current in the 2-wire ohms function as a troubleshooting tool in itself.

4-2. DC VOLTAGE MEASUREMENT

When measuring dc voltages in high-impedance circuits, there are two possible sources of error to consider: circuit loading and input bias current.

4-3. Circuit Loading Error

Whenever a voltmeter is connected to a circuit, the voltmeter's internal resistance changes the voltage of the circuit under test. The resulting error is called circuit loading error. The error is negligible as long as the resistance of the circuit under test (the source impedance) is small compared to the input impedance of the meter. As the source impedance approaches the input impedance of the voltmeter, the error can be considerable. The percentage of error can be calculated using the formula in Figure 4-1.

The input impedance of the 8840A is 10 MΩ in the 200V and 1000V ranges, and is greater than 10,000 MΩ in the 200 mV, 2V, and 20V ranges. Therefore, for the 8840A, circuit loading error is less than 0.01% as long as the source impedance is less than 1 MΩ in the 200 mV, 2V, and 20V ranges, and less than 1 kΩ in the 200V and 1000V ranges. The exceptionally high input impedance on the 20V dc range allows high-accuracy readings in CMOS and high-impedance analog circuitry.

NOTE

Input protection circuitry can reduce the input impedance to as low as 100 kΩ when the input is overrange. This may also occur momentarily when the instrument autoranges to a higher range.

4-4. Input Bias Current Error

Input bias current error occurs because a voltmeter's input bias current always changes the voltage of the circuit under test. However, the error is significant only when measuring voltages in circuits with very high source impedance. The error can be measured as shown in Figure 4-2.

With the 8840A, it is easy to correct for this error using the OFFSET button:

1. Select the VDC function and the desired range.
2. Connect the 8840A INPUT terminals to a resistor which matches the source impedance of the circuit to be tested.
3. Allow the displayed reading to settle.
4. Press the OFFSET button.
5. Remove the resistor.
6. Proceed with the desired measurement.

Example:

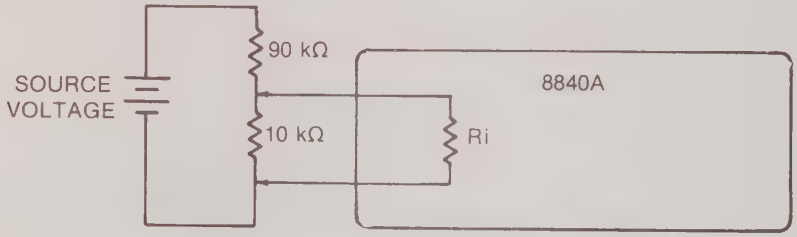
Measure a 1.5V source with 1 MΩ source impedance, correcting for input bias current.

$$\text{CIRCUIT LOADING ERROR IN \%} = \frac{100 \times Rs}{Rs + Ri}$$

where Rs = Source impedance
Ri = 8840A input impedance
(Ri =>10,000 MΩ in 200 mV, 2V, and 20V ranges)
(Ri = 10 MΩ in 200V and 1000V ranges)

EXAMPLE

When measuring the voltage across the 10 kΩ leg of a 90 kΩ over 10 kΩ voltage divider, the circuit loading error is less than 0.1% in the upper ranges, and less than 0.0001% in the lower ranges:



$$Rs = \frac{(90\ k\Omega) \times (10\ k\Omega)}{90\ k\Omega + 10\ k\Omega} = 9\ k\Omega$$

$$\text{Error in the 200V and 1000V ranges} = 100 \times \frac{9\ k\Omega}{9\ k\Omega + 10\ M\Omega} = 0.09\%$$

$$\text{Error in the 200 mV, 2V and 20V ranges} = 100 \times \frac{9\ k\Omega}{9\ k\Omega + 10{,}000\ M\Omega} = 0.00009\%$$

Figure 4-1. Circuit Loading Error Calculation

1. Connect a 1 MΩ resistor between the INPUT HI and INPUT LO terminals.
2. Select the VDC function and the 2V range.
3. Allow the display to settle.
4. Press OFFSET. (This zeroes the input bias current error.)
5. Remove the 1 MΩ resistor.
6. Measure the voltage of the circuit under test.

Note that this procedure does not correct for circuit loading error. Also note that if input bias current error is not corrected for, it may be added to the circuit loading error.

4-5. RESISTANCE MEASUREMENT

The 8840A allows you to measure resistance in both 2-wire and 4-wire configurations. Each has its benefits.

4-6. 2-Wire Ohms

Two-Wire ohms measurements are simple to set up and yield good results for most measurement conditions. Measurements are made as shown in Figure 4-3. An internal current source (the "ohms current source") passes a known test current (ITEST) through the resistance being tested (RUNKNOWN). The 8840A measures the voltage drop across RUNKNOWN, calculates RUNKNOWN using Ohm's law (RUNKNOWN = VTEST/ITEST), and displays the result.

The test current and full-scale voltage for each resistance range are shown in Table 4-1. Since the HI INPUT test lead is positive with respect to the LO INPUT lead, these test leads are not interchangeable when a semiconductor device is being measured.

4-7. Correcting for Test Lead Resistance in 2-Wire Ohms

In 2-wire ohms, the resistance of the test leads can introduce error when measuring low resistances. Typical test leads may add as much as 0.5Ω to 2-wire ohms readings.

TO MEASURE INPUT BIAS CURRENT ERROR:

1. Select the VDC function and the desired range.
2. Eliminate any offset voltages by shorting the HI INPUT and LO INPUT terminals and then pressing OFFSET.
3. Select a resistor which matches the source impedance (R_{SOURCE}) of the circuit to be tested, and connect it to the HI INPUT and LO INPUT terminals.
4. Allow the circuit to settle.
5. Record the displayed voltage. This is the input bias current error (V_{ERROR}).

The input bias current error may be calculated as a percentage as follows:

$$\text{ERROR (IN \%)} = \frac{V_{ERROR}}{\text{VOLTAGE MEASUREMENT}} \times 100\%$$

The input bias current itself (I_{BIAS}) may be calculated as follows:

$$I_{BIAS} = \frac{V_{ERROR}}{R_{SOURCE}}$$

Figure 4-2. Measuring Input Bias Current Error

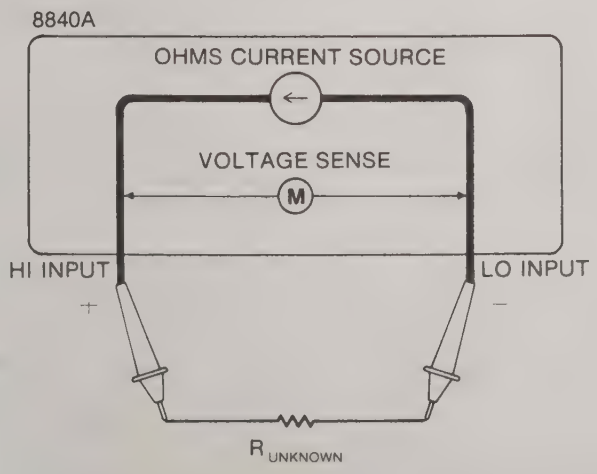


Figure 4-3. 2-Wire Ohms Measurement

With the 8840A, it is easy to correct for this error using the OFFSET button:

1. Select the 2-wire ohms function.
2. Touch the test leads together. The 8840A should indicate the resistance of the test leads.
3. With the test leads still touching, press the OFFSET button. The 8840A should read 0Ω.

4-8. 4-Wire Ohms

Four-Wire ohms measurements provide the highest accuracy for low resistance measurements. The 4-wire configuration automatically corrects for both test lead resistance and contact resistance. Contact resistance (the resistance between the test probe tips and the circuit being tested) is unpredictable, and therefore cannot be reliably corrected with a fixed offset.

Four-Wire ohms measurements are especially important when using long test leads. In a typical automated test system, for example, the test leads could be connected through four or five switching relays, each with 2Ω of resistance!

The 8840A makes 4-wire ohms measurements as shown in Figure 4-4. The HI and LO INPUT leads apply a known, internal current source to the unknown resistance, just as in 2-wire ohms. (See Table 4-1.) However, the voltage drop across the unknown resistance is measured with the SENSE leads rather than the INPUT leads. Since the current flow in the SENSE leads is negligible, the error caused by the voltage drop across the leads is also negligible.

NOTE

In the 2 MΩ and 20 MΩ ranges of the 4-wire ohms function, the voltage across the unknown resistance is sensed between the HI SENSE and LO INPUT terminals. Accuracy is not affected as long as the resistance of the LO INPUT lead is less than 10Ω in the 2 MΩ range, and less than 100Ω in the 20 MΩ range.

Table 4-1. Ohms Test Current

RANGE	TEST CURRENT	FULL SCALE VOLTAGE
200Ω	1 mA	0.2V
2 kΩ	1 mA	2.0V
20 kΩ	100 μA	2.0V
200 kΩ	10 μA	2.0V
2000 kΩ	5 μA	10.0V
20 MΩ	500 nA	10.0V

4-9. Applications of the Ohms Functions

The 2-wire and 4-wire ohms functions can be used for a variety of purposes in addition to measuring resistance, as the following applications show.

4-10. TESTING DIODES

The 2-wire ohms function can also be used to test diodes.

1. Select the 2-wire ohms function and the 2 kΩ range.
2. Measure the resistance of the diode. If the diode is good, when forward-biased it will measure about 0.6 kΩ to 0.7 kΩ for silicon (0.25 kΩ to 0.3 kΩ for germanium), and when reverse-biased it will cause the 8840A to indicate overrange. (The forward-biased reading depends upon the range used.)

The 2 kΩ range is used because its 1 mA test current provides a typical operating point, and its 2V full-scale voltage is sufficient to turn on most diodes (even two diodes in series).

4-11. TESTING ELECTROLYTIC CAPACITORS

The 2-wire ohms function can also give a rough test of an electrolytic capacitor's leakage and dielectric absorption. This test works well for capacitors 0.5 μF and larger.

1. Select the 2-wire ohms function, the 2 kΩ range, and the medium reading rate.
2. Connect the test leads to the capacitor (with the INPUT HI lead to the + lead and the INPUT LO lead to the - lead). The 8840A will try to charge it to the open-circuit voltage of the 2 kΩ range (about 6V).
3. Disconnect the + test lead.
4. To test for leakage, select the VDC function and the 20V range (leave the 8840A in the medium reading rate), and measure the voltage that was stored on the capacitor during step 2.
   a. If the capacitor is good, the voltage across the capacitor will be about 6V, and will be relatively stable.
   b. If the capacitor is leaky, the voltage across the capacitor will be much less than 6V, and the voltage will be decreasing. The rate of change depends on how leaky the capacitor is.
   c. With some electrolytic capacitors, the reading will increase. This usually indicates the capacitor is defective.

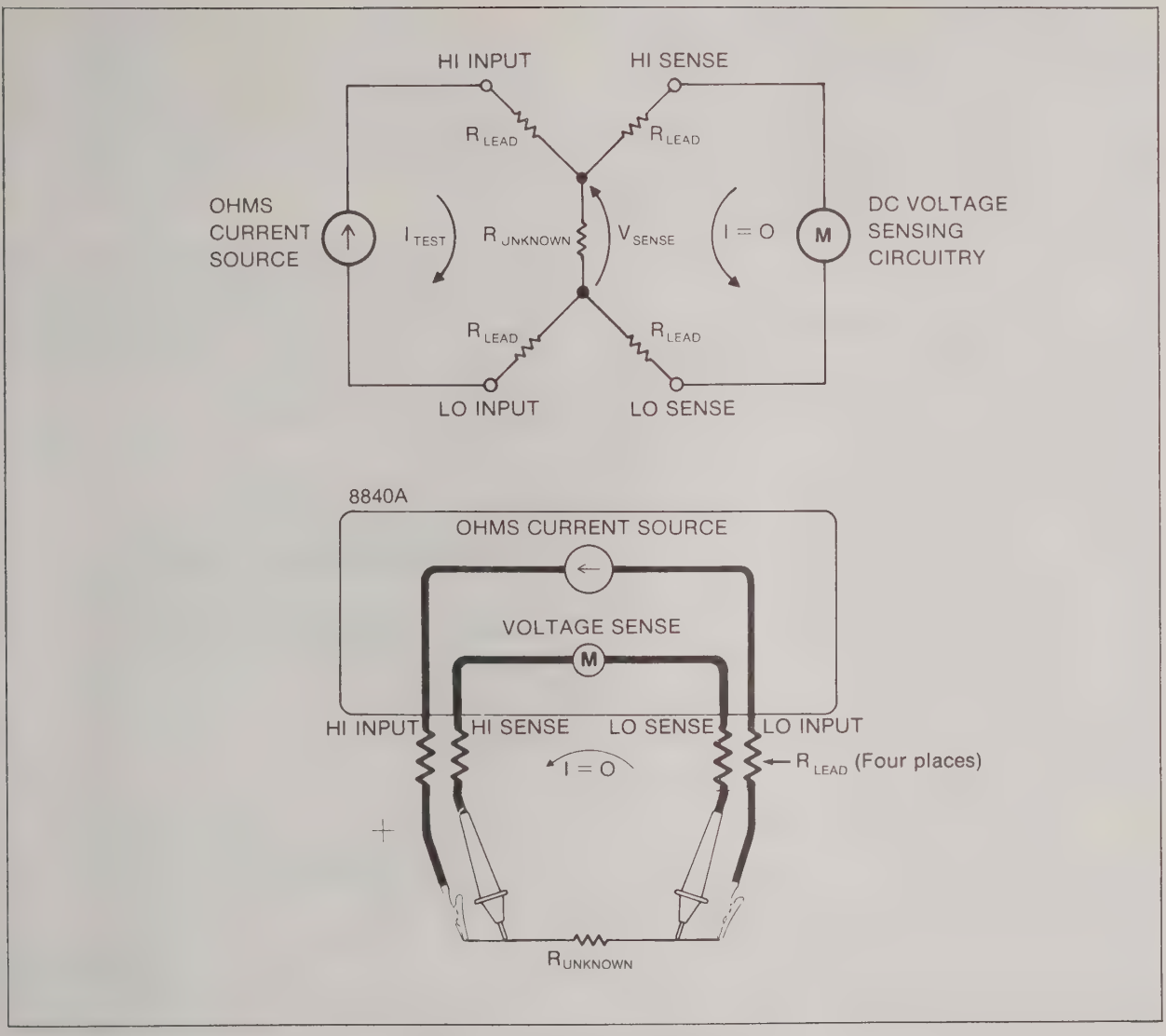


Figure 4-4. 4-Wire Ohms Measurement

5. To test the capacitor's dielectric absorption, briefly short the capacitor's leads together and then measure the voltage across the capacitor.

   a. If the dielectric is good (i.e., has low dielectric absorption), the voltage across the capacitor will be nearly zero volts.

   b. If the dielectric is poor (i.e., has high dielectric absorption), the voltage across the capacitor will be significantly above zero.

4-12. A PRECISION CURRENT SOURCE

The ohms current source (the internal current source used in the ohms functions) makes a useful troubleshooting tool in itself. It has excellent linearity and temperature stability. Its compliance voltage is typically 5V in the lower four ohms ranges, and 12V in the upper two ohms ranges. The inputs are protected against accidental applications of voltage up to 300V rms.

To use the ohms current source, connect the test leads to the HI and LO INPUTS, and select either the 2-wire or 4-wire ohms function. Press the range buttons to select any of the current levels shown in Table 4-1.

The ohms current source can be used to troubleshoot circuits by injecting current into selected nodes, forcing the circuits to be in a specific test state. For example, the ohms current source can be used to set or modify the bias of amplifier circuits. The current level can be changed simply by changing range.

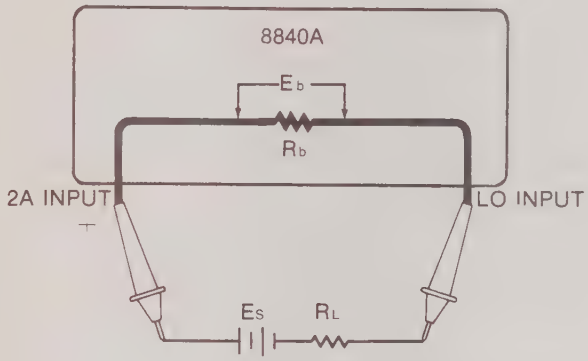
The ohms current source can also be used to test mA or μA panel meters. The accuracy of the current source is more than enough to verify panel meters, whose accuracy is typically 1% to 5%. To test an analog panel meter, simply connect the current source across the meter movement (as though measuring its resistance). A 1 mA meter should show full scale when the ohms function is set on the 2 kΩ range. The same technique also works with digital panel meters.

4-13. DC CURRENT MEASUREMENT

To get the best accuracy using the mA DC function, it is important to understand the concept of burden voltage error.

When a meter is placed in series with a circuit to measure current, error can be caused by the small voltage drop across the meter (in this case, across the protective fuses and current shunt). This voltage drop is called the burden voltage, and it is highest for full-scale measurements. The full-scale burden voltage for the 8840A is typically less than 1V.

The burden voltage can present a significant error if the current source being measured is unregulated (i.e., not a true current source) and if the resistance of the fuse and shunt is a significant part of the source resistance. If burden voltage does present a significant error, the percentage of error can be calculated and corrected for using the formulas in Figure 4-5.



E_s = Source voltage (measured)
E_b = Burden voltage (measured)
R_L = Load + source resistance
R_b = 8840A internal resistance

$$\text{ERROR IN mA} = (\text{Displayed current}) \times \frac{E_b}{E_s - E_b}$$

$$\text{ERROR IN PERCENT} = \frac{E_b}{E_s} \times 100$$

EXAMPLE:

Displayed current = 1460 mA
E_s = 15V (measured with 8840A in VDC function)
E_b = 0.4V (measured with 8840A as described below)

$$\text{Error in percent} = \frac{0.4\text{V}}{15\text{V}} \times 100 = 2.67\%$$

$$\text{Error in mA} = (1460\text{ mA}) \times \frac{0.4\text{V}}{15\text{V} - 0.4\text{V}} = 40\text{ mA}$$

To get the correct current, add the error in mA to the displayed current:

Correct current = 1460 mA + 40 mA = 1500 mA

NOTE: MEASURING BURDEN VOLTAGE

The 8840A allows you to measure burden voltage (E_b) directly. Leaving the 2A and LO INPUT leads in place for current measurement, select the VDC function. Then, connect a third lead to the HI INPUT terminal and with it measure voltage at the 2A terminal.

Figure 4-5. Burden Voltage Error Calculation

4-14. REDUCING THERMAL VOLTAGES

When making very low-level dc measurements, thermal voltages can present an additional source of error. Thermal voltages are the thermovoltaic potentials generated at the junction between dissimilar metals. Thermal voltages typically occur at binding posts and can be greater than 10 μV.

Thermal voltages can also cause problems in the low ohms ranges. Some low-value resistors are constructed with dissimilar metals. Just handling such resistors can cause thermal voltages large enough to introduce measurement errors.

The effect of thermal voltages can be reduced by using the following techniques:

1. Use tight connections.
2. Use clean connections (especially free of grease and dirt).
3. Use similar metals for connections wherever possible (e.g., copper-to-copper, gold-to-gold, etc.).
4. Use caution when handling the circuit under test.
5. Wait for the circuit to reach thermal equilibrium. (Thermal voltages are generated only where there is a temperature gradient.)

4-15. AC VOLTAGE AND CURRENT MEASUREMENT

When making precise measurements of ac voltage and current, there are several considerations in addition to those discussed under dc voltage and current measurement. These include the concepts of rms conversion, crest factor, bandwidth, and zero-input error.

4-16. True RMS Measurement

The True RMS AC Option measures the true rms value of ac voltages and currents. In physical terms, the rms (root-mean-square) value of a waveform is the equivalent dc value that causes the same amount of heat to be dissipated in a resistor. True rms measurement greatly simplifies the analysis of complex ac signals. Since the rms value is the dc equivalent of the original waveform, it provides a reliable basis for comparing dissimilar waveforms.

By contrast, many meters in use today use average-responding ac converters rather than true rms converters. The scale factor in these meters is adjusted so that they display the rms value for harmonic-free sinusoids. However, if a signal is not sinusoidal, average-responding meters do not display correct rms readings.

The 8840A actually derives the rms value using analog computation. This means that the 8840A readings represent true rms values not only for harmonic-free sinusoids, but also for mixed frequencies, modulated signals, square waves, sawtooths, random noise, rectangular pulses with 10% duty cycle, etc.

4-17. Waveform Comparison

Figure 4-6 illustrates the relationship between ac and dc components for common waveforms, and compares readings for true rms meters and average-responding meters. For example, consider the first waveform, a 1.41421V (zero-to-peak) sine wave. Both the 8840A and rms-calibrated average-responding meters display the correct rms reading of 1.00000V (the dc component equals 0). However, consider the 2V (peak-to-peak) square wave. Both types of meter correctly measure the dc component (0V), but only the 8840A correctly measures the ac component (1.00000V). The average-responding meter measures 1.110V, which amounts to an 11% error.

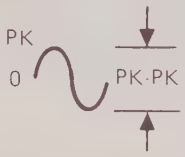
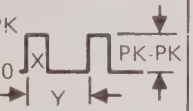
Since average-responding meters have been in use for so long, you may have accumulated test or reference data based on them. The conversion factors in Figure 4-6 should help you convert between the two measurement methods.

4-18. Crest Factor

Crest factors are useful for expressing the ability of an instrument to measure a variety of waveforms accurately. The crest factor of a waveform is the ratio of its peak voltage to its rms voltage. (For waveforms where the positive and negative half-cycles have different peak voltages, the more extreme peak is used in computing the crest factor.) Crest factors start at 1.0 for square waves (for which the peak voltage equals the rms voltage) and increase for more "pointed" waveforms as shown in Figure 4-7.

The 8840A has a full-scale crest factor limit of 3.0 for the 20V and 700V ranges, and 6.0 for the other ranges. For full-scale input signals with a crest factor above these limits, dynamic range limitations can begin to cause large errors. However, as Figure 4-7 shows, signals with a crest factor above 3.0 are unusual.

If you don't know the crest factor of a particular waveform but wish to know if it falls within the crest factor limit of the 8840A, measure the signal with both the 8840A and an ac-coupled oscilloscope. If the rms reading on the 8840A is 1/3 or more of the waveform's zero-to-peak voltage, the crest factor is 3.0 or less.

AC-COUPLED INPUT WAVEFORM	PEAK VOLTAGES		METERED VOLTAGES			DC AND AC TOTAL RMS
			AC COMPONENT ONLY		DC COMPONENT ONLY	
	PK-PK	0-PK	RMS CAL*	8840A		TRUE RMS = $\sqrt{ac^2 + dc^2}$
SINE 	2.828	1.414	1.000	1.000	0.000	1.000
RECTIFIED SINE (FULL WAVE)	1.414	1.414	0.421	0.435	0.900	1.000
RECTIFIED SINE (HALF WAVE)	2.000	2.000	0.764	0.771	0.636	1.000
SQUARE	2.000	1.000	1.110	1.000	0.000	1.000
RECTIFIED SQUARE	1.414	1.414	0.785	0.707	0.707	1.000
RECTANGULAR PULSE  $D = X/Y$ $K = D - D^2$	2.000	2.000	2.22K	2K	2D	$2\sqrt{D}$
TRIANGLE SAWTOOTH	3.464	1.732	0.960	1.000	0.000	1.000

* RMS CAL IS THE DISPLAYED VALUE FOR AVERAGE RESPONDING METERS THAT ARE CALIBRATED TO DISPLAY RMS FOR SINE WAVES

Figure 4-6. Waveform Comparison Chart

4-19. AC-Coupled AC Measurements

Input signals are ac-coupled in the ac functions. One of the advantages of ac coupling is that ac measurements can be made on power supply outputs, phone lines, etc. Ripple measurements, for instance, cannot be made with dc coupling. Remember, however, that when the 8840A measures signals with the ac functions, the reading on the display does not include the dc component (if one exists). For example, consider Figure 4-8, which shows a simple ac signal riding on a dc level. The VAC function would measure the ac component only.

4-20. Combined AC and DC Measurements

The 8840A can be used to evaluate the true rms value of waveforms such as the one shown in Figure 4-8, which includes both ac and dc components. First, measure the rms value of the ac component using the VAC function. Next, measure the dc component using the VDC function. Finally, calculate the total rms value as follows:

$$V_{RMS} = \sqrt{V_{AC}^2 + V_{DC}^2}$$

WAVEFORM	CREST FACTOR
SQUARE WAVE	1.0
SINE WAVE	1.414
TRIANGLE SAWTOOTH	1.732
MIXED FREQUENCIES	1.414 to 2.0
SCR OUTPUT OF 100% – 10%	1.414 to 3.0
WHITE NOISE	3.0 to 4.0
AC COUPLED PULSE TRAIN (t_0, T, t_0 = 1/10 T)	3.0
SPIKE	> 9.0

Figure 4-7. Typical Crest Factors for Various Waveforms

4-21. Bandwidth

Bandwidth defines the range of frequencies to which an instrument can respond accurately. The accuracy of the 8840A is specified for sinusoidal waveforms up to 100 kHz, or for nonsinusoidal waveforms with frequency components up to 100 kHz. The small-signal bandwidth (the frequency at which the response is 3 dB down) is typically around 300 kHz.

For signals with components greater than 100 kHz, the measurement accuracy is reduced because of frequency bandwidth and slew-rate limitations. Because of this, accuracy may be reduced when measuring signals with fast rise times, such as high-frequency square waves or switching supply waveforms. As a rule of thumb, an ac voltage input signal is within the bandwidth limitations if the rise time is longer than 2 us, and within the slew-rate limitations if the input slew rate is slower than (1V/μs)x(full scale of range).

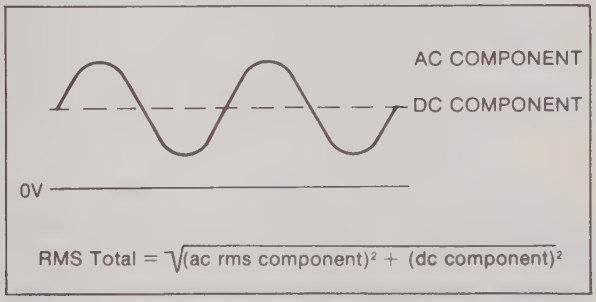


Figure 4-8. Combined AC and DC Measurement

4-22. Zero-Input VAC Error

If the 8840A input terminals are shorted while the VAC function is selected, the 8840A displays a non-zero reading (typically less than 80 digits in the highest four ranges, and less than 300 digits in the 200 mV range). Such readings are due to random noise combined with the inherent nonlinear response of computing-type rms converters to very small input signals.

The zero-input error is quickly reduced when the input is increased. The rms converter error (a dc error) and the internally generated noise (a random ac error) are both uncorrelated with the input signal. Therefore, when a signal is applied, the resulting reading is not the simple addition of the signal and the zero-input error, but the square root of the sum of their squares. This reduces the effect of the error, as shown in the example in Figure 4-9.

As long as the 8840A reading is 1,000 counts or more, readings will still be within specified accuracy.

EXAMPLE

Given a zero-input reading of 300 counts (0.300 mV in the 200 mV range) and an input signal of 10 mV, the 8840A might read:

$$\sqrt{10^2 + 0.300^2} = \sqrt{100 + 0.090} = 10.004 \text{ mV}$$

The effect of the zero-input error is reduced from 0.300 mV to 0.004 mV.

Figure 4-9. Reduction of Zero-Input Error

Section 5
Theory of Operation

5-1. INTRODUCTION

This section presents an overall functional description of the 8840A, followed by a detailed circuit description. The descriptions are supported by simplified schematics in text and by the complete schematics in Section 10.

5-2. OVERALL FUNCTIONAL DESCRIPTION

A functional block diagram of the 8840A is shown in Figure 5-1. The basic signal path flows from left to right across the center of the page. The input is sensed at the input terminals, scaled, directed through the Track/Hold circuit, converted into digital representation by the Analog-to-Digital (A/D) Converter, processed by the Digital Controller, and sent to the display.

The DC Scaling circuit, which constitutes the "front end" of the instrument, has two major functions. First, it senses the input and produces an equivalent dc voltage for all functions except VAC and mA AC. (AC inputs are converted to a dc voltage by the True RMS AC Option.) Resistances are sensed as a dc voltage using a known test current from the Ohms Current Source. A dc current input is converted to a dc voltage by a precision current shunt.

Second, the DC Scaling circuit scales the equivalent dc voltages (for in-range inputs) to within the input range of the A/D Converter (±2V). In addition, the DC Scaling circuit provides input protection and provides analog filtering for certain ranges and reading rates. (AC inputs are scaled by the True RMS AC Option.)

The Track/Hold (T/H) circuit samples the scaled dc voltage and presents the A/D Converter with a voltage that is constant for the input portion of each A/D conversion cycle. The T/H circuit also provides additional scaling for certain ranges.

The Digital Controller controls the operation of virtually every part of the 8840A. It reads the front panel keyboard, configures the instrument for each function and range, triggers the A/D Converter, calculates the result of each A/D conversion cycle, averages A/D samples, controls the display, and communicates with the IEEE-488 Interface Option via the Guard Crossing circuit. The heart of the Digital Controller is the In-Guard Microcomputer (μC).

The Guard Crossing circuit permits serial asynchronous communication between the Digital Controller and the IEEE-488 Interface Option, while isolating the two circuits electrically. Whereas the in-guard power supply floats with the voltage at the INPUT LO terminal, the IEEE-488 Interface Option operates with reference to earth ground. The "guard" is the isolation between the in-guard and out-guard circuits.

The Power Supply provides supply voltages to all parts of the instrument. The Precision Voltage Reference provides precise reference voltages for the A/D Converter and the Ohms Current Source.

5-3. DETAILED CIRCUIT DESCRIPTION

The following paragraphs give a detailed circuit description of each of the functional blocks in Figure 5-1. For clarity, measurement ranges are referred to as r1, r2, r3, etc., where r1 is the lowest possible range, r2 the next higher range, and so on. Pins are designated by the respective integrated circuit (e.g., U101-7 for U101 pin 7).

5-4. DC SCALING

The DC Scaling circuit scales all in-range dc inputs so that the output of the Track/Hold (T/H) amplifier (U307) is within ±2V. In addition, the DC Scaling circuit provides input protection and analog filtering. Additional scaling is provided by the the T/H Amplifier.

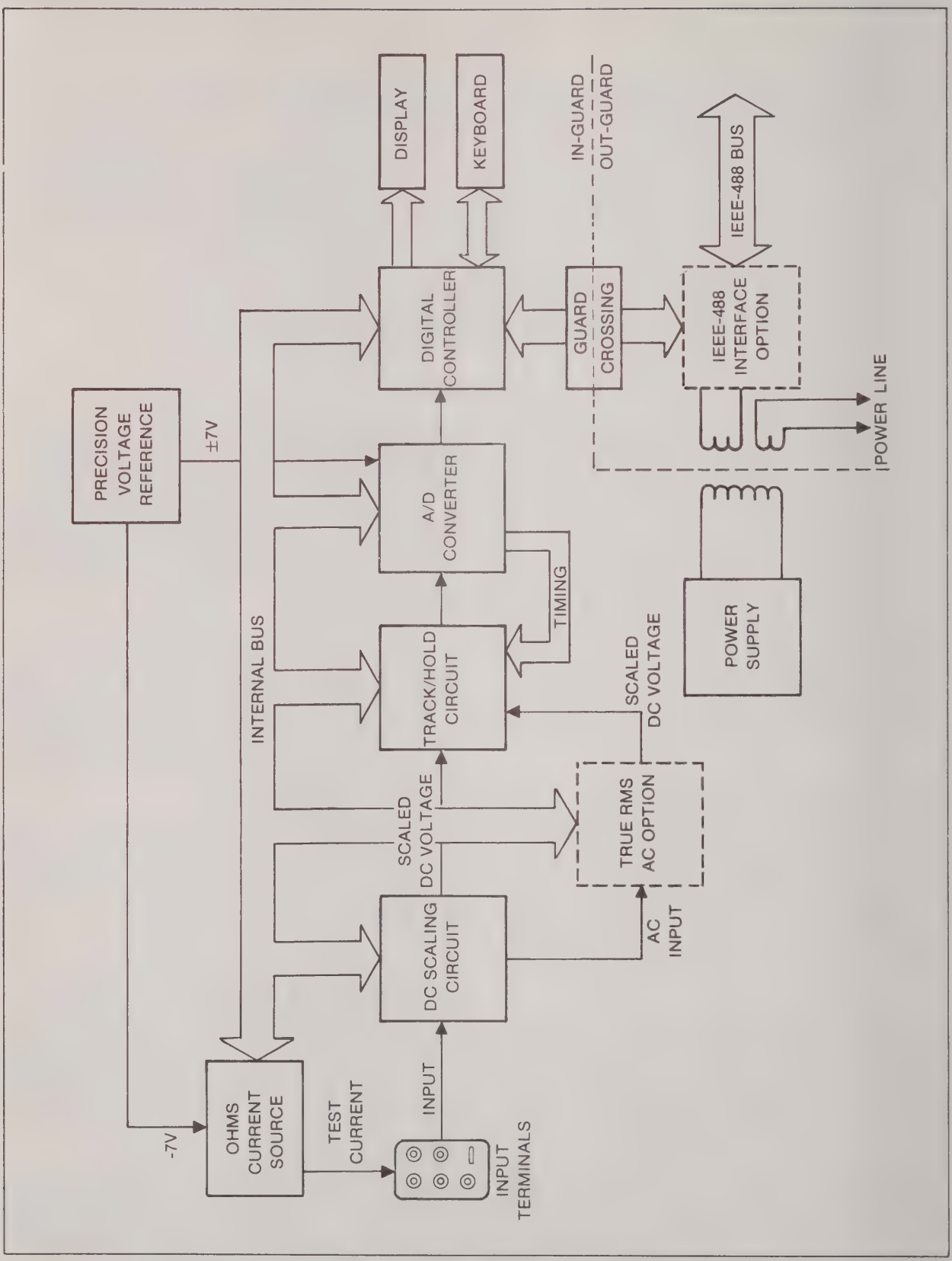


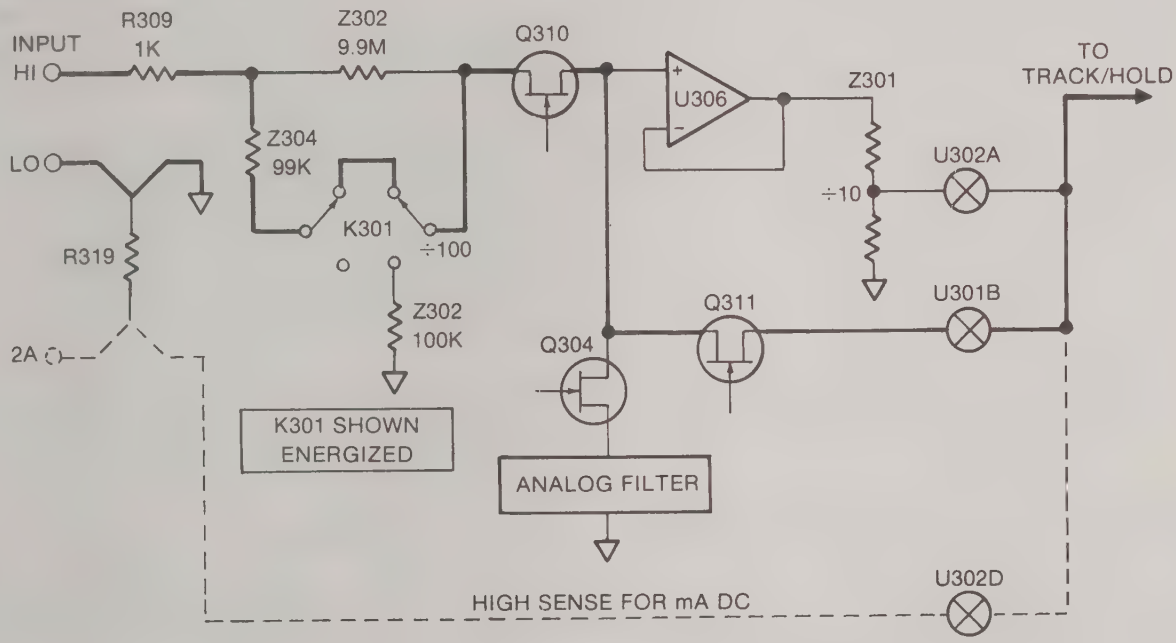
Figure 5-1. Overall Functional Block Diagram

The following paragraphs describe the configuration of the DC Scaling circuit in the DCV and mA DC functions and also describe the analog filter. The ohms functions are described under a later heading because the T/H Amplifier provides additional input switching for these functions.

5-5. VDC Scaling

Scaling is performed in the VDC function by two precision resistors networks (Z301 and Z302). These components are configured by relay K301, switching transistor Q311, and quad analog switches U302A and U301B to provide the correct scaling for each range. Voltage follower U306 provides high input impedance for the 20V dc range. A simplified schematic and a switch state table for the VDC function are shown in Figure 5-2.

In the 200 mV and and 2V ranges, the input voltage is applied directly to the T/H Amplifier via Q310, Q311, and U301B. In the 200 mV range, the T/H Amplifier has a gain of 10; in all other dc voltage ranges, the T/H Amplifier has a gain of 1.



SWITCH STATES FOR VDC

RANGE	Q310	K301	Q311 & U301B	U302A	U302D
200 mV	•	•	•		
2V	•	•	•		
20V	•	•		•	
200V	•		•		
1000 V	•			•	

NOTE

TABLES SHOW CONFIGURATION DURING TRACK PERIOD OF TRACK/HOLD CYCLE.

FILTER SWITCH Q304 IS ON FOR THE S READING RATE IN VDC.

SWITCH STATES FOR mA DC

RANGE	Q310	K301	Q311 & U301B	U302A	U302D
200 mA	•				•

• = Switch closed (or relay energized).

Figure 5-2. DC Scaling (VDC and mA DC)

In the 20V range, the input voltage is buffered by unity-gain amplifier U306, and divided by 10 by Z301. To allow U306 to handle ±20V inputs, its power supplies are "bootstrapped" by Q305 and Q306, so that the output voltage of U306 determines the midpoint of its supply voltages. The positive supply is approximately 6.2V above the input and the negative supply is approximately 6.2V below.

In the 200V and 1000V ranges, K301 is de-energized and the input voltage is divided by 100 by Z302. In the 200V range, the reduced input voltage is then applied directly to the T/H Amplifier as in the 2V range. In the 1000V range, the reduced input voltage is buffered by U306 and divided by 10 as in the 20V range.

5-6. VDC Protection

Input protection for the VDC function is provided by a 1K, fusible resistor (R309), four metal-oxide varistors (MOVs) (RV301, RV402, RV403, and RV404), and additional protection resistors and clamp circuits.

WARNING

TO AVOID INJURY OR EQUIPMENT DAMAGE, USE EXACT REPLACEMENT PARTS FOR ALL PROTECTION COM—PONENTS.

In all dc voltage ranges, voltage transients greater than 1560V are clamped by the MOVs. Extreme overvoltage conditions cause R309 to fail open-circuit.

R309 is followed either by a 99 kΩ, 10W resistor network (Z304) in the 200 mV, 2V, and 20V ranges, or by 10 MΩ (Z302) to ground in the 200V and 1000V ranges. Z304 provides current limiting in extreme overvoltage conditions in the 200 mV, 2V, and 20V ranges. The non-inverting input of U306 is clamped to ±25V by Q307 and Q308.

5-7. mA DC Scaling

In the mA DC function, the unknown current causes a voltage drop across current shunt R319. This voltage drop is then measured as in the VDC function. The DC Scaling circuit is configured as shown by the simplified switch table in Figure 5-2.

5-8. Analog Filter

The three-pole, low-pass analog filter (U304) has a Butterworth response with corner frequency at 7 Hz, giving approximately 50 dB of rejection at 50 Hz. The filter is used only for the slow reading rate and is used only in the VDC ranges and lowest three ohms ranges. The filter is switched into the input signal path by Q304 (Figure 5-2). In some ranges and functions, additional filtering is provided by U302B and C314.

5-9. TRACK/HOLD CIRCUIT

The Track/Hold (T/H) circuit presents a stable voltage to the A/D Converter during the input period of the A/D conversion cycle. The circuit also provides a gain of 10 in the 200 mV dc, 200Ω, and 2000 mA dc ranges.

The T/H circuit consists of the T/H Amplifier (Figure 5-3), T/H capacitor C308, quad analog switches U301, U302, and U303, and associated components. As shown in Figure 5-3, the T/H Amplifier functions as an op amp, with Q314 supplying additional gain. In subsequent figures, the T/H Amplifier is represented as a single op amp.

The circuit operates by cycling between the track, settling, hold, and precharge configurations shown in Figure 5-4. The In-Guard μC selects a particular settling and hold configuration for each function and range, and suppresses the precharge configuration for certain ranges. This control is achieved by latching function and range information in U301, U302, and U303.

Basic timing for the T/H circuit is provided by the A/D Converter over clock lines PC, HD1, TR1, and TR2. (See the timing diagram in Figure 5-5, top.) The T/H cycle is initiated when the In-Guard μC pulls line TR low.

5-10. Track Configuration

In the track configuration (Figure 5-4A), the T/H circuit functions as a non-inverting buffer. The voltage on C308 tracks the scaled dc input voltage.

5-11. Settling Configuration

The circuit assumes a settling configuration between the track and hold configurations. The circuit assumes the configuration in Figure 5-4B for unity gain and the configuration in Figure 5-4C for gain of 10.

During this time the DC Scaling circuit is still connected to the T/H amp. However, changes in the input do not affect the value to be measured, which is stored on C308.

5-12. Hold Configuration

The X1 hold configuration (Figure 5-4D) is used for all VDC ranges except r1 and for all ohms ranges except r1. The output of U307 is the negative of the input voltage.

The X10 hold configuration (Figure 5-4E) is used for the mA DC function, the 200 mV dc range, and the 200Ω range, and provides a gain of 10.

5-13. Pre-Charge Configuration

The pre-charge configuration (Figure 5-4F) occurs after the hold configuration in VDC ranges r1, r2, and r4, and ohms ranges r1, r2, r3, and r4. U306 is connected as a buffer to charge stray capacitance at the non-inverting input of the T/H Amplifier. The pre-charge configuration is not used in any other ranges.

5-14. PRECISION VOLTAGE REFERENCE

The Precision Voltage Reference (Figure 5-6) provides precise reference voltages of –7.00000 and +7.00000. The reference element is a reference amplifier (ref amp). The nominal ref amp voltage is 6.5V.

Resistor R701, precision resistor network Z701, and transistor/zener diode combination U701 are produced as a matched set so that the output of U702A is precisely -7.00000V. This output is remotely sensed at the pins of the custom A/D IC (U101). Diode CR701 prevents the output from going positive at power-up.

U702B functions as an inverter to provide the +7.00000V output and to supply the reference amplifier. The gain of U702B is set by the two 20 kΩ resistors in the resistor network Z702.

5-15. OHMS CURRENT SOURCE

The Ohms Current Source (Figure 5-7) provides a precise test current for the ohms functions. The first stage (U401, R401, and Q401) produces a precise reference current, using precision resistor R401 and a –7.0000V reference voltage from the Precision Voltage Reference.

The second stage (U404, precision resistor network Z401, and analog switches U402 and U403) is a current amplifier whose gain is controlled by the In-Guard μC. The In-Guard μC sets the output current for each range by controlling U402 and U403. (See switch state table in Figure 5-7.)

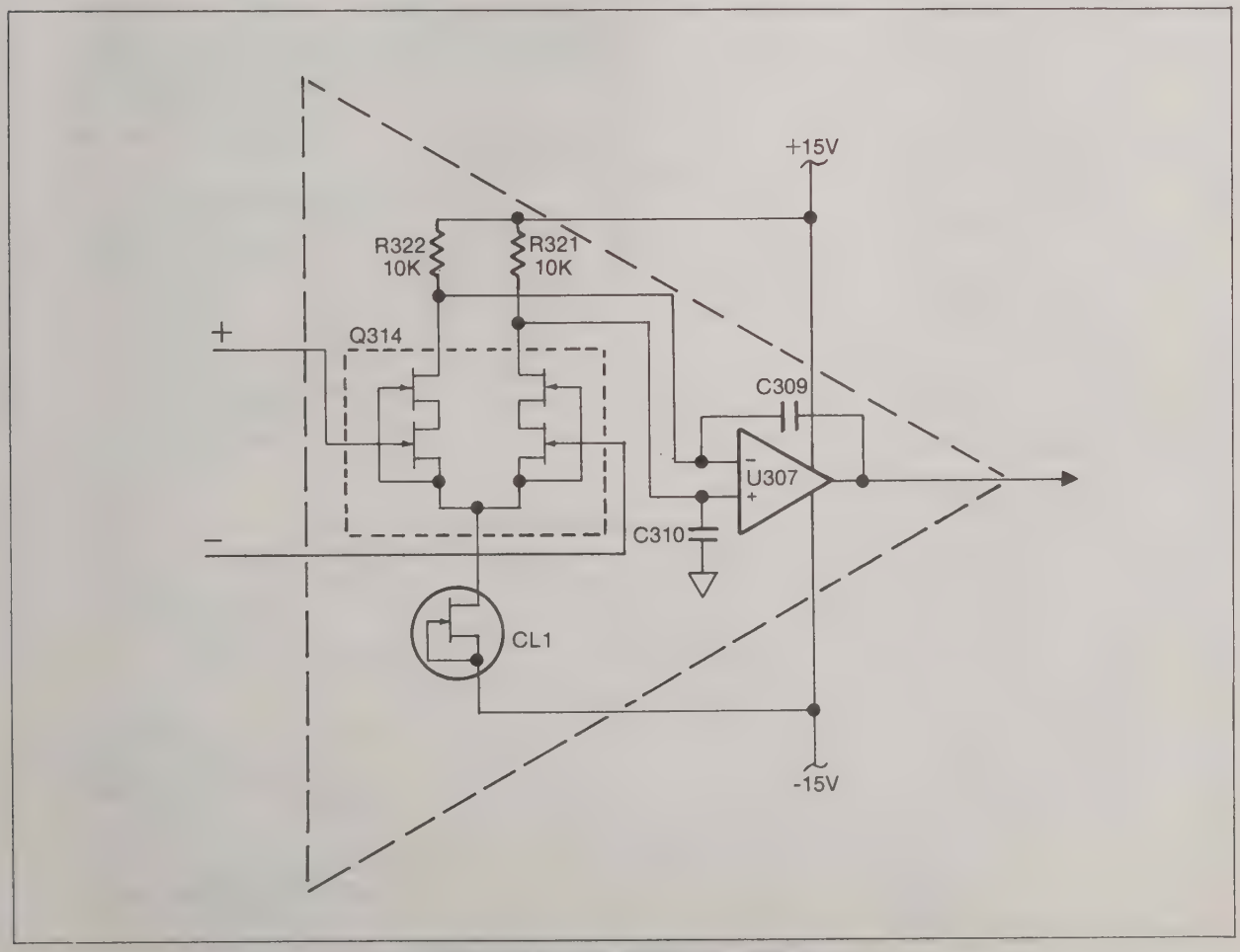


Figure 5-3. Track/Hold Amplifier

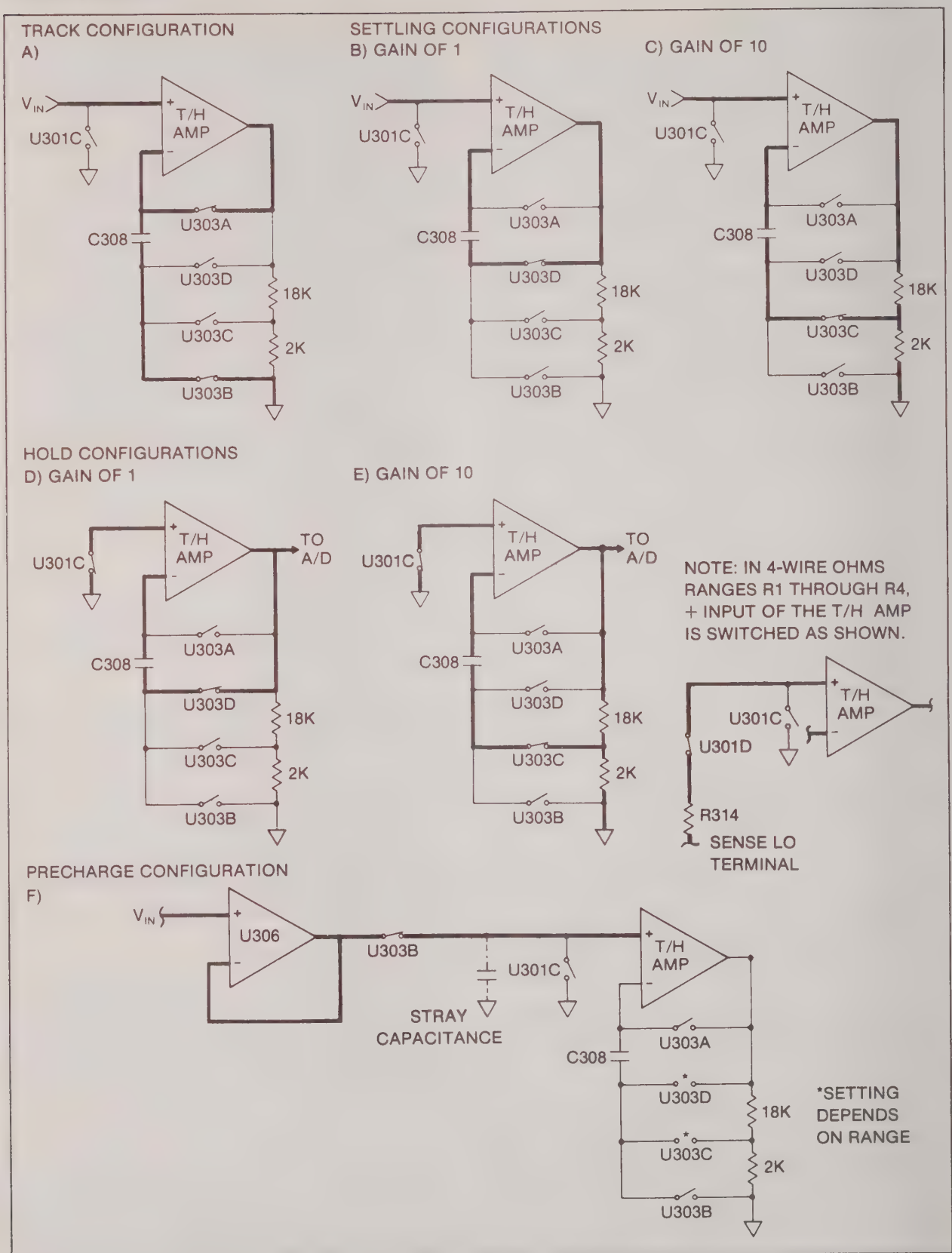
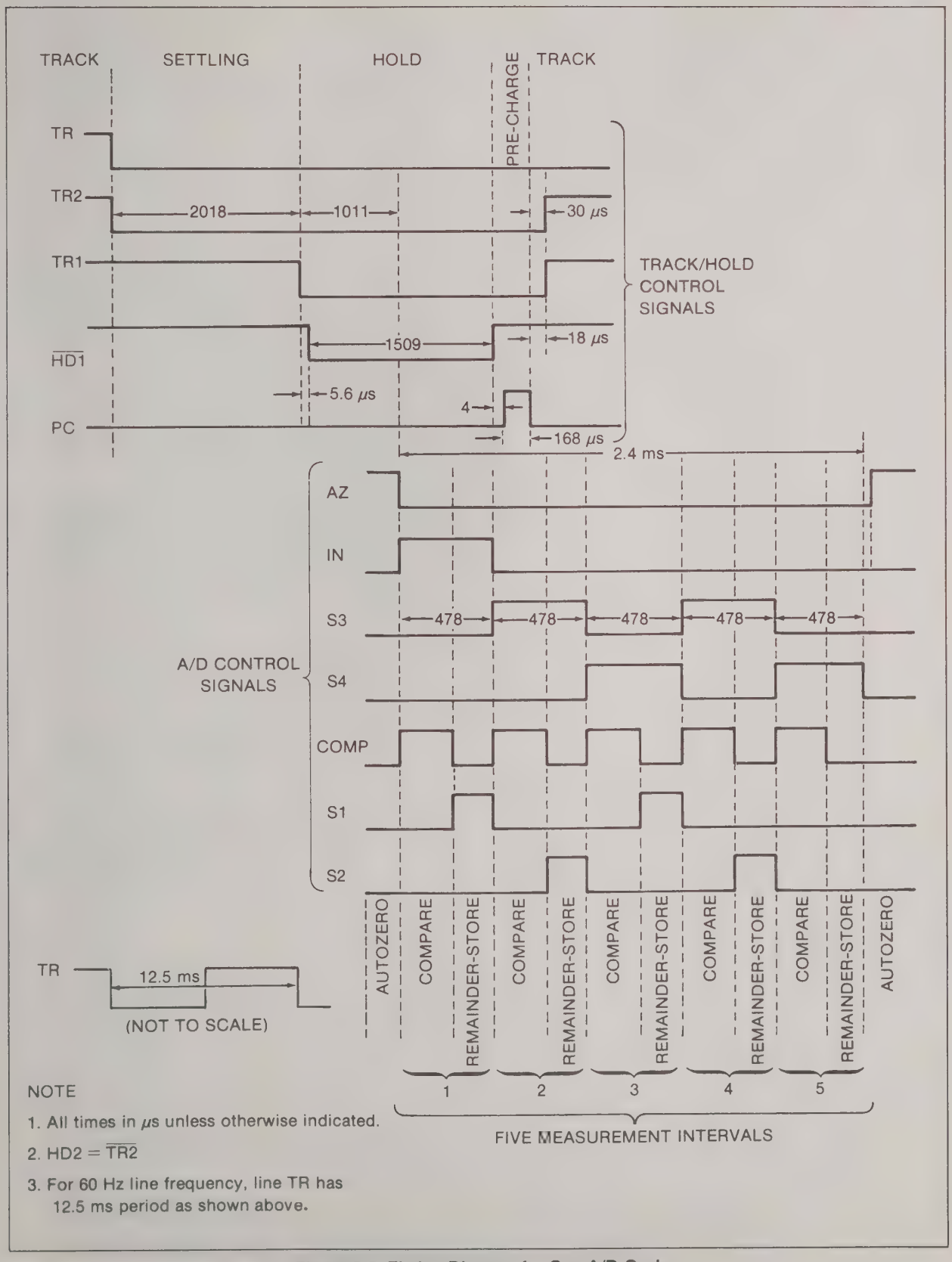


Figure 5-4. Track/Hold Circuit Configurations



NOTE

1. All times in μs unless otherwise indicated.
2. HD2 = $\overline{TR2}$
3. For 60 Hz line frequency, line TR has 12.5 ms period as shown above.

Figure 5-5. Timing Diagram for One A/D Cycle

5-16. OHMS PROTECTION

The Ohms Protection circuit (Q402, Q403, Q404, Q405, Q406, and Q407) clamps the open circuit voltage of the Ohms Current Source and provides protection for the Ohms Current Source.The circuit protects the Ohms Current Source from up to ±300V across the INPUT terminals. The circuit also clamps voltage transients larger than 1560V with four MOVs (RV401, RV402, RV403, and RV404). In addition, a 1 kΩ, 2W fusible wire-wound resistor (R410) in series with the output current path fails open-circuit under extreme overvoltage conditions.

Large positive input voltages are blocked by CR402. Large negative input voltages are dropped equally across three high-voltage transistors (Q402, Q403, and Q404). If -300V is present at the collector of Q404, the voltage drops equally across Z402 so that large negative voltages never reach the current source.

The circuitry associated with Q408 (R406, R407, R408, R409, Q406, Q408, and CR403) clamps the open-circuit voltage of the Ohms Current Source below +6.5V in the lower four ranges and below +13V dc in the higher two ranges. The in-guard μC turns Q408 on or off depending on range. In the lower four ohms ranges, Q408 is on, effectively shorting R409; R406 and R409 then form a voltage divider which clamps the output of the ohms current source below +6.5V. In the higher two ohms ranges, Q408 is off, including R409 in the voltage divider and clamping the output below +13V.

5-17. OHMS FUNCTIONS

5-18. 2-Wire Ohms

In the 2-wire ohms function, the Ohms Current Source is connected to the INPUT HI terminal by ohms relay K401 (Figure 5-8). The Ohms Current Source applies a known current to the resistance under test, and the resulting voltage drop across the resistor is measured ("sensed") as in the VDC function.

The voltage sensed at the INPUT terminals is scaled as shown by the simplified switch table in Figure 5-8. (Refer to the track period of the track/hold cycle, during which the scaled input voltage is sampled.)

In the lower four ranges, the full scale input voltage to the A/D Converter is 2V. However, in the 2000 kΩ and 20 MΩ ranges, the full-scale input voltage to the A/D Converter is +1V; the in-guard μC completes the scaling by multiplying the A/D result by 2.

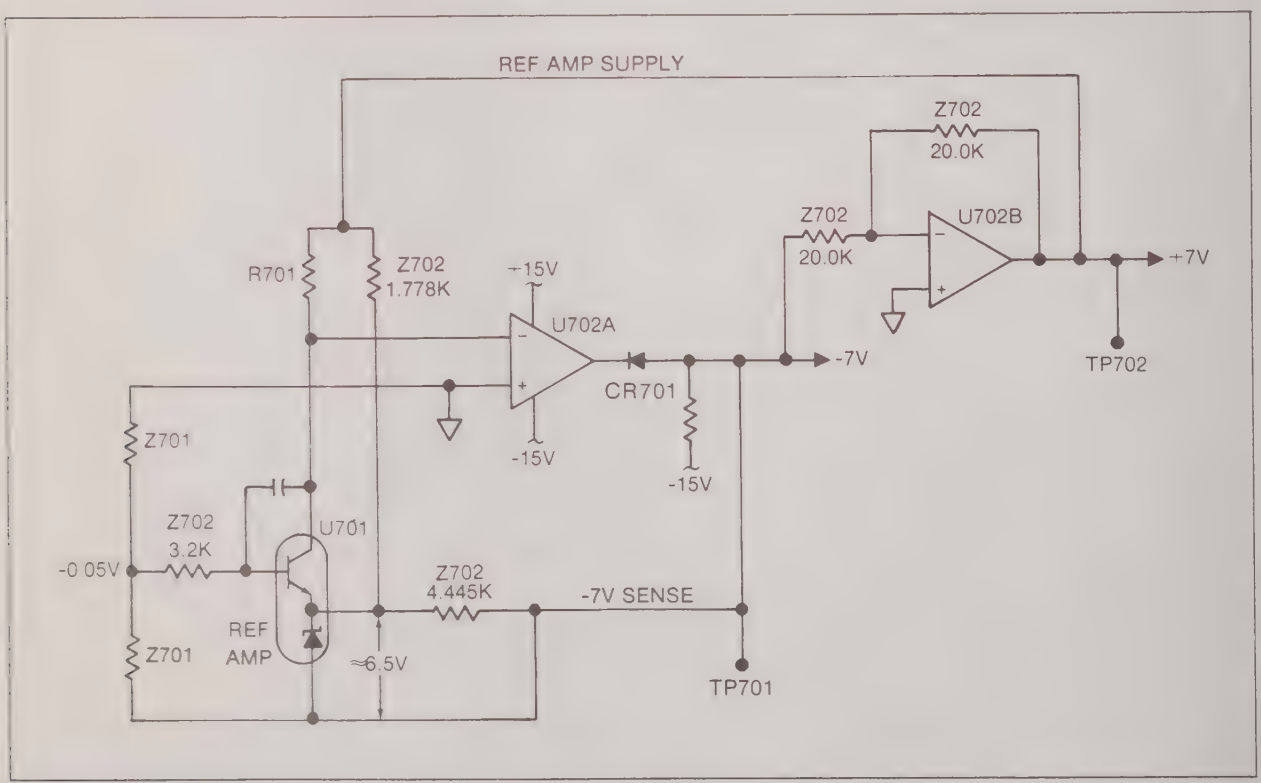


Figure 5-6. Precision Voltage Reference

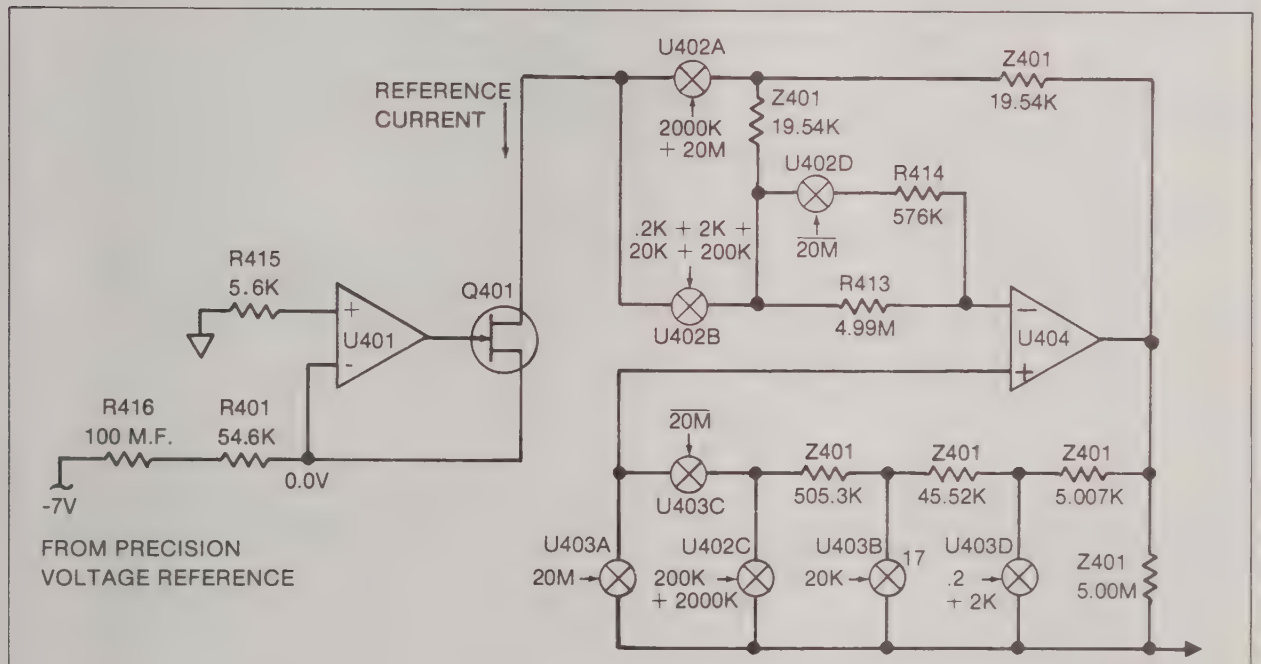
5-19. 4-Wire Ohms

In the 4-wire ohms function, the Ohms Current Source is connected to the INPUT HI terminal by ohms relay K401 as in 2-wire ohms (Figure 5-8). The Ohms Current Source applies a known current to the resistance under test through the INPUT HI and INPUT LO leads. The resulting voltage drop across the resistor is measured by the SENSE HI and SENSE LO leads.

The voltage at the SENSE HI terminal is connected to the DC Scaling circuit by Q303 (Figure 5-8). The voltage is then scaled exactly as in the 2-wire ohms function. (Refer to the track period in the switch table in Figure 5-8.) Q310 is turned off to isolate the SENSE HI terminal from the INPUT HI terminal.

Additional input switching occurs during the hold period of the track/hold cycle. (Refer to the hold period in the switch table in Figure 5-8.) In ranges r1 through r4, the SENSE LO terminal is switched into the dc input path by U301D, and the INPUT LO terminal is switched out of the dc input path by U301C. This has the effect of measuring the SENSE HI terminal with respect to the SENSE LO terminal.

In ranges r5 and r6, the SENSE LO and INPUT LO terminals are both switched into the dc input path by U301C and U301D during the hold period. This has the effect of measuring the SENSE HI terminal with respect to INPUT LO terminal rather than SENSE LO. Although the resistance of the INPUT LO lead is in series with the unknown resistance, accuracy is not affected as long as the resistance of the lead is less than 10Ω in the 2000K Ω range and less than 100Ω in the 20 MΩ range.

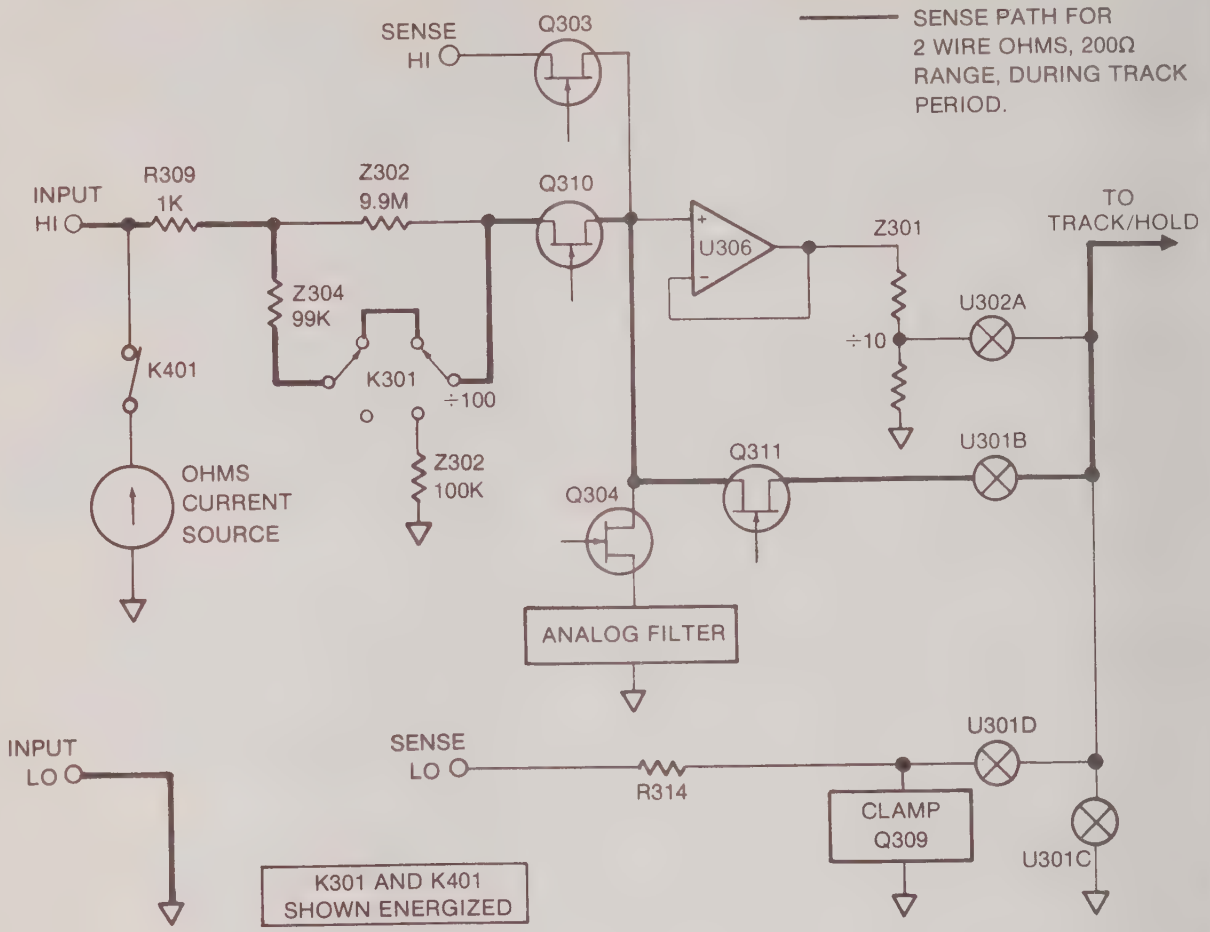


SWITCH STATE TABLE

RANGE	U402A	U402B	U402C	U402D	U403A	U403B	U403C	U403D
200Ω		•		•			•	•
2 kΩ		•		•			•	•
20 kΩ		•		•		•	•	
200 kΩ		•	•	•			•	
2000 kΩ	•		•	•			•	
20 MΩ	•				•			

• = Switch closed

Figure 5-7. Ohms Current Source



PERIOD	RANGE	K401	Q310	Q303	K301	Q311	U301B	U302A	U301C	U301D
TRACK	200Ω	•	2	4	•	•	•			
	2 kΩ	•	2	4	•	•	•			
	20 kΩ	•	2	4	•	•	•			
	200 kΩ	•	2	4	•	•	•			
	2000 kΩ	•	2	4	•			•		
	20 MΩ	•	2	4	•			•		
HOLD	200Ω	•	2	4	•	•			2	4
	2 kΩ	•	2	4	•	•			2	4
	20 kΩ	•	2	4	•	•			2	4
	200 kΩ	•	2	4	•	•			2	4
	2000 kΩ	•	2	4	•				•	•
	20 MΩ	•	2	4	•				•	•

• = Switch closed (or relay energized).
2 = Switch closed only in 2 WIRE ohms.
4 = Switch closed only in 4 WIRE ohms.

NOTE: Filter switch Q304 is for the S reading rate, ranges r1, r2, and r3.

Figure 5-8. Ohms Scaling

5-20. A/D CONVERTER

The Analog-to-Digital (A/D) Converter (Figure 5-9) uses Fluke's patented recirculating remainder technique. An input voltage (V_{in}) is compared to the output of the precision Digital-to-Analog Converter (DAC). The output of the A/D Amplifier, connected as a comparator, is monitored to indicate when the DAC output is larger than the input voltage.

The conversion process is broken up into an autozero period followed by five measurement intervals. (A timing diagram is shown in Figure 5-5.) Six bits of the final A/D sample are obtained during each interval.

During the first compare period (shown in Figure 5-9), the A/D Converter determines the value of the scaled input voltage (V_{in}) by comparing V_{in} to the output of the DAC. Each of the DAC bit-switches is tried in sequence and kept or rejected (left closed or reopened) depending on the output polarity of the A/D Amplifier, which is configured as a comparator. This process produces a string of six bits which is stored in the Timing/Data Control circuit (the digital portion of U101).

During the following remainder-store period (Figure 5-10), the difference between the V_{in} and the DAC output is multiplied by 16 by the A/D Amplifier and stored on capacitor C102. During subsequent compare and remainder-store periods, the remainder voltage is connected to the input of U103 and is resolved to six bits; the remainder voltage (multiplied by 16) is stored alternately on capacitor C102 and C103. Each of the five compare periods thus produces a six-bit nibble which is stored in the Timing/Data Control circuit.

This five-interval process thus generates five nibbles which are processed by the In-Guard μC to produce one A/D sample. After the fifth nibble is generated, U101 interrupts the In-Guard μC over line INT. The In-Guard μC then pulls line CS7 low five times, causing U101 to send the μC the five (six-bit) nibbles one-at-a-time over lines AD0-AD5. The In-Guard μC then weights each nibble 1/16 of the value of the previous number and calculates the input voltage.

The hardware for the A/D Converter has four major sections: Timing/Data Control, Precision DAC, A/D Amplifier, and bootstrap supplies.

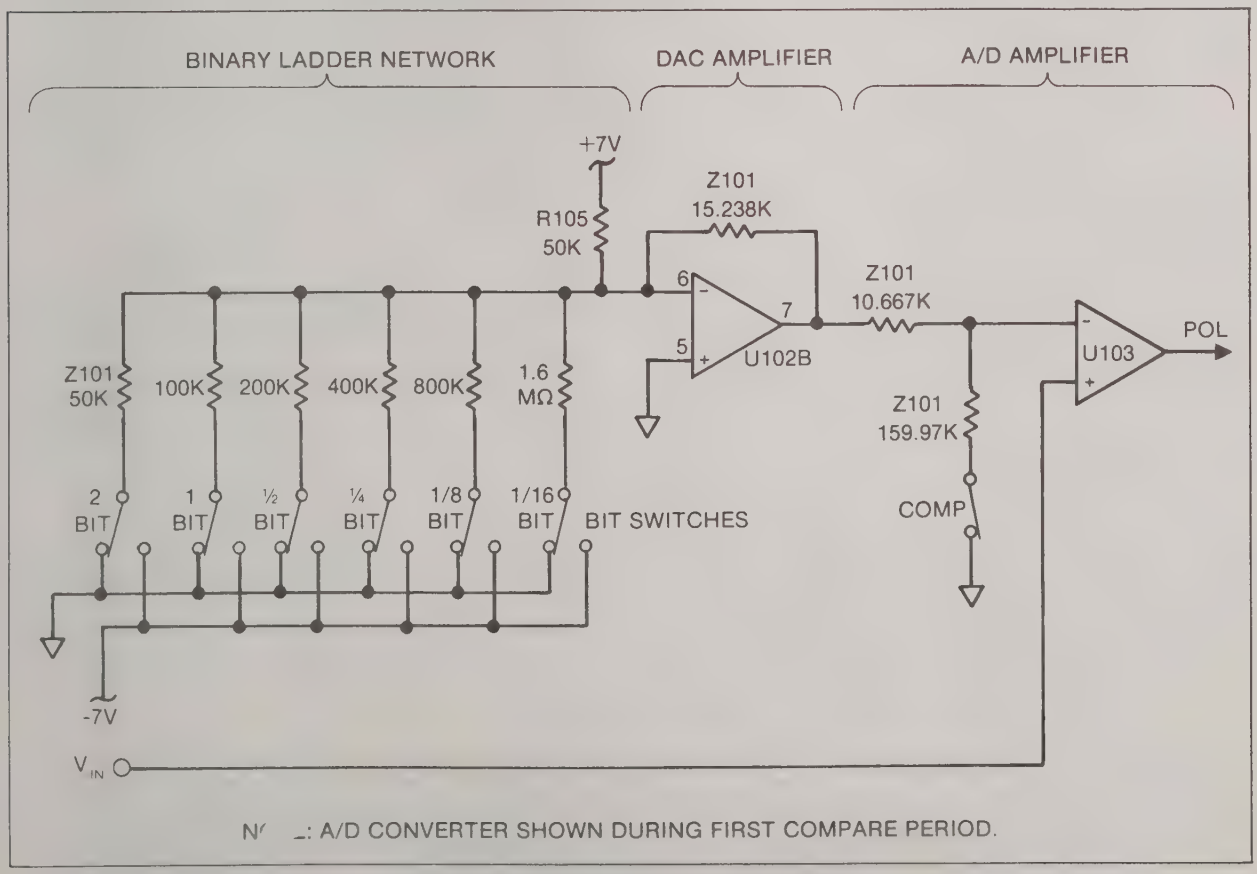


Figure 5-9. Analog-to-Digital Converter

5-21. Timing/Data Control

The Timing/Data Control circuit (the digital portion of U101) times and controls the A/D Converter by manipulating the switches in the A/D Amplifier and the bit-switches in the Precision DAC. An A/D conversion cycle is triggered by the falling edge of line TR from the In-Guard μC. Once triggered, the A/D Converter (under control by U101) generates the five 6-bit nibbles without further interaction with the In-Guard μC.

The Timing/Data Control circuit also provides a watchdog timer (line $\overline{RES}$) which resets the In-Guard μC in case normal program execution is interrupted. If the timer senses inactivity on line CS7 for longer than 1.5 seconds, it resets the In-Guard μC by pulling $\overline{RES}$ low.

The Timing/Data Control circuit is supplied with a fixed-rate 8 MHz clock and provides a 1 MHz output clock for the Keyboard/Display Interface (U212). In addition, four output lines (PC, $\overline{HDI}$, TR1, and TR2) provide control signals for the Track/Hold circuit.

5-22. Precision DAC

The Precision Digital-to-Analog Converter (DAC) is composed of DAC Amplifier U102B and a binary ladder network, which consists of resistors in Z101 and digitally controlled analog bit-switches contained in U101.

The bit-switches determine the output voltage of U102B by controlling the binary ladder network. The gain of U102B is set by the ratio of a precision feedback resistor (Z101-7,-8) and the equivalent output resistance of the ladder network.

5-23. A/D Amplifier

The A/D Amplifier is composed of a comparator/amplifier (U103), two remainder-storage capacitors (C103 and C102), an autozero storage capacitor (C101), and several digitally controlled analog switches contained in U101.

The A/D Amplifier has three modes of operation: autozero mode, where any offsets in the A/D input are stored on C101 so as to be cancelled later; compare mode, where the A/D input is compared to the DAC output; and remainder-store mode, where U103 amplifies and stores the difference between the A/D input and the DAC output on one of the two remainder-storage capacitors (C102 or C103). The autozero mode is shown in Figure 5-11. The other modes are shown in Figures 5-9 and 5-10.

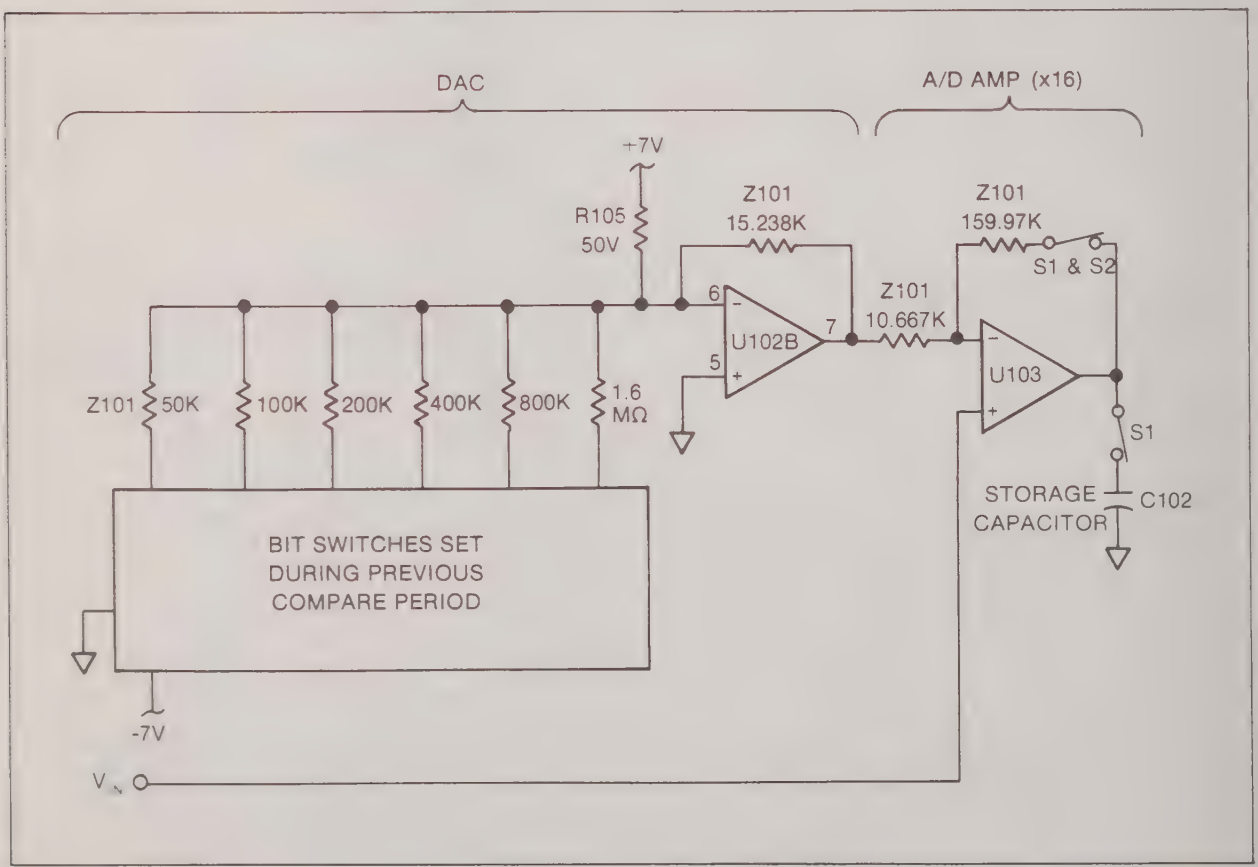


Figure 5-10. First Remainder-Store Period

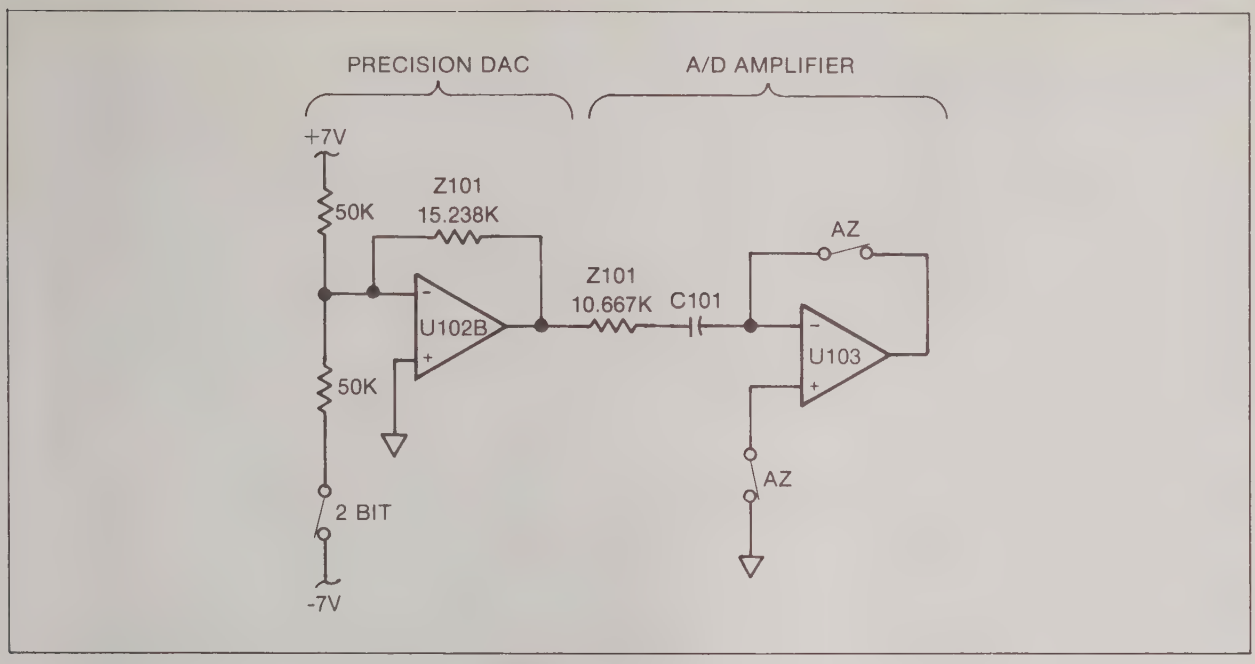


Figure 5-11. Autozero Period

5-24. Bootstrap Supplies

The bootstrap supplies are composed of U102A, Q101, Q102, CR103, CR104, and associated components. The Bootstrap Supplies enhance the gain accuracy of U103. During compare periods, the bootstrap supplies limit the output of U103 to minimize the time it takes to recover from being driven to a supply rail. Both functions are achieved by manipulating the supplies of U103 (BS1 and BS2).

5-25. DISPLAY

The vacuum fluorescent display is similar to a vacuum tube, containing eight control grids and 69 phosphor-coated plates which form the display segments and annunciators. (See Figure 5-12.) The filament voltage is 4.5V ac, with a +5V dc bias. Each plate is controlled by a G line and a P line. The G lines go to the control grids, and the P lines go to the plates.

The Digital Controller sequentially enables the G lines by applying +30V dc (nominal). When a G line is enabled, electrons flow from the filament to the enabled grid. If a P line is enabled (i.e., raised to a nominal +30V dc by the Digital Controller), the electrons continue past the grid and strike the respective plate, causing it to glow.

5-26. KEYBOARD

The keyboard consists of a silicone-rubber switch matrix located over metalized epoxy contacts on the printed wire board. Each button contains a conductive pad that shorts two contacts when pressed.

5-27. DIGITAL CONTROLLER

The Digital Controller (Figure 5-13) consists of the In-Guard μC (U202), External Program Memory (U222), Calibration Memory (U220), Keyboard/Display Interface, and associated components.

5-28. In-Guard Microcomputer

The In-Guard Microcomputer (μC) is a single-chip Z8 microcomputer containing 4K bytes of ROM, 144 bytes of RAM, a UART, and four 8-bit I/O ports. It communicates with the rest of the instrument via the internal bus and dedicated I/O lines. The In-Guard μC is reset when pin 6 is pulled low either by C204 at power-up or by the watch-dog timer in the custom A/D IC (U101). Pin 6 is tied to +5V through a 100 kΩ resistor inside the μC.

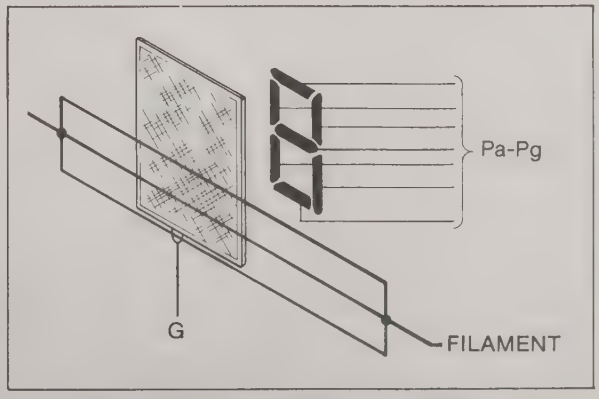


Figure 5-12. Vacuum Fluorescent Display

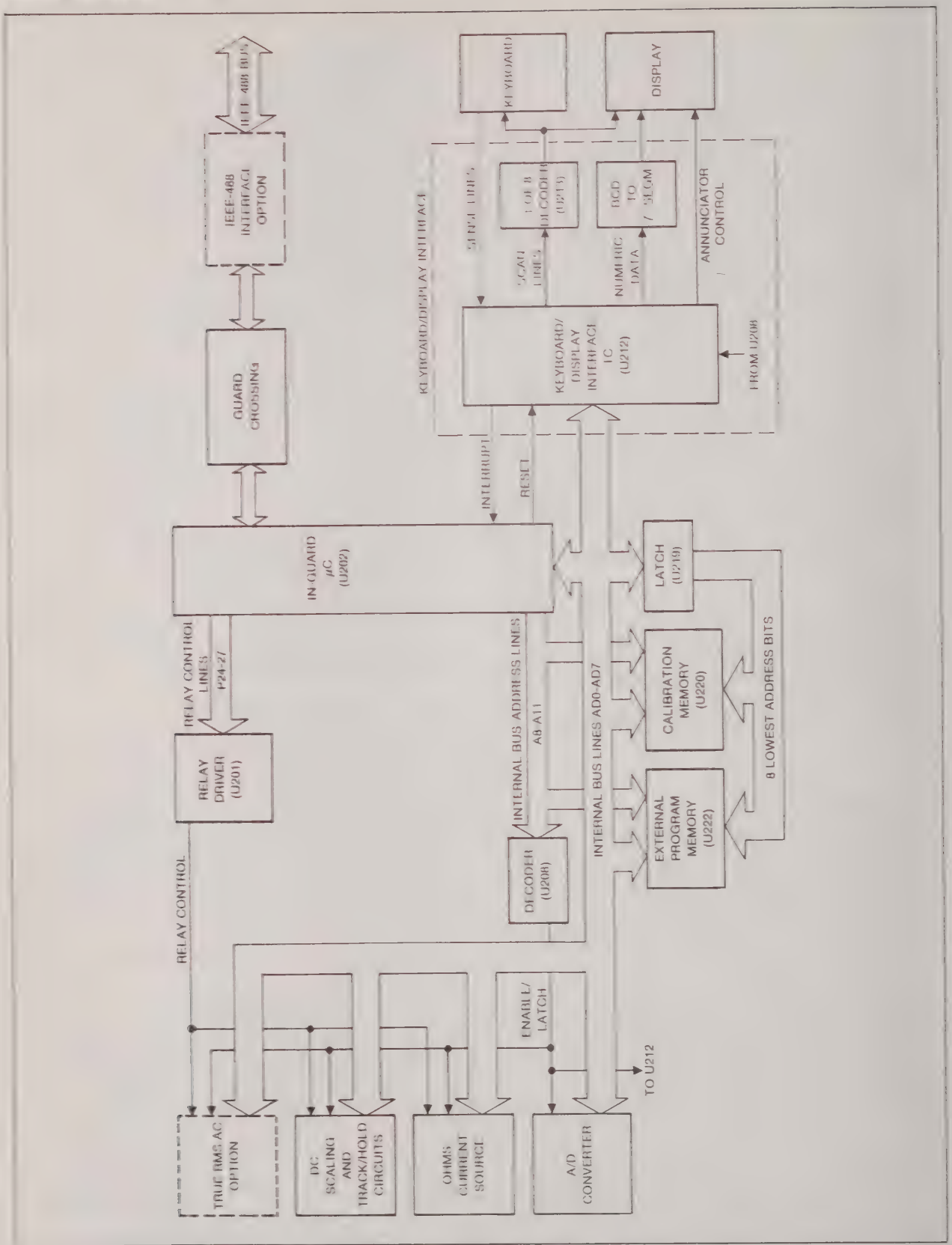


Figure 5-13. Digital Controller Block Diagram

All internal bus communication is memory-mapped. Each component that sends or receives data on the bus has a unique address or range of addresses. The internal bus consists of lines AD0-AD7 and A8-A11. Lines AD0-AD7 are time-multiplexed to carry both the least-significant address byte and the data. Lines A8-A11 carry the most-significant bits of the address. The μC writes to and reads from the internal bus according to the read and write cycles shown in Figure 5-14. During either cycle, the address strobe (AS) changes from low to high when an address is valid, and the data strobe (DS) changes from low to high when the data is valid.

The address strobe latches the address on AD0-AD7 into U219 which then provides static address inputs for those devices that need it while data is on the bus. The data memory line (DM) divides the address space between program memory (U222) and data memory (all other devices on the bus). The data memory address space is further divided between the calibration memory (U220) and the remaining devices by A11. The addresses of the remaining devices are decoded from A8-A10 by U208, which combines the address with the data strobe (DS) to provide a chip select (CS0, CS2, CS3, CS4, or CS7) for each device.

The In-Guard μC performs the following functions: range and function control; A/D control and computation; calibration corrections; keyboard display control; serial communication with the IEEE-488 Interface; and diagnostic self-testing and troubleshooting.

5-29. Function and Range Control

The In-Guard μC configures the DC Scaling circuit, the Track Hold circuit, and the Ohms Current Source to provide the proper input switching, scaling, and filtering for each function, range, and reading rate. It does this by controlling dedicated output lines which control relays and FET switches, and by sending configuration codes out on the bus. The quad analog switches (U301, U302, U303, U402, and U403) latch the configuration codes and perform any level-shifting needed to control their internal MOSFET switches. Some of the switches require dynamic timing signals from the custom A/D IC (U101); these signals are combined appropriately in the quad analog switches with the configuration codes.

5-30. A/D Control and Computation

The In-Guard μC initiates each A/D sample by pulling line TR low. When the μC is reset, it senses the power line frequency on line FREQ REF. The μC then sets its internal timer so that the A/D sample rate is as shown in Table 5-1.

The number of readings per second for the slow and medium rates are chosen to provide rejection of input signals that are at the line frequencies.

The custom A/D IC (U101) generates five 6-bit numbers after each trigger from the μC and then pulls INT low, telling the μC that data is ready. The μC reads the five 6-bit numbers over the bus (CS7 pulses low five times for five read cycles) and computes the value of the A/D sample using calibration constants. The μC averages the appropriate number of samples for one reading, which is then sent to the keyboard display interface for display.

For example, with a 60-Hz power-line frequency, an externally triggered reading in the slow reading rate would cause the μC to send 32 pulses on TR at an 80 Hz rate. The 32 A/D samples would be calibrated and averaged by the μC and sent for display. With internal triggering, the A/D runs continuously at 80 samples per second with a reading being sent to the display every 32 samples.

5-31. Calibration Correction

The calibration constants used by the In-Guard μC in computing each reading are stored in the EEROM (electronically erasable read-only memory) Calibration Memory (U220). The front panel CAL ENABLE switch protects the EEROM from accidental writes.

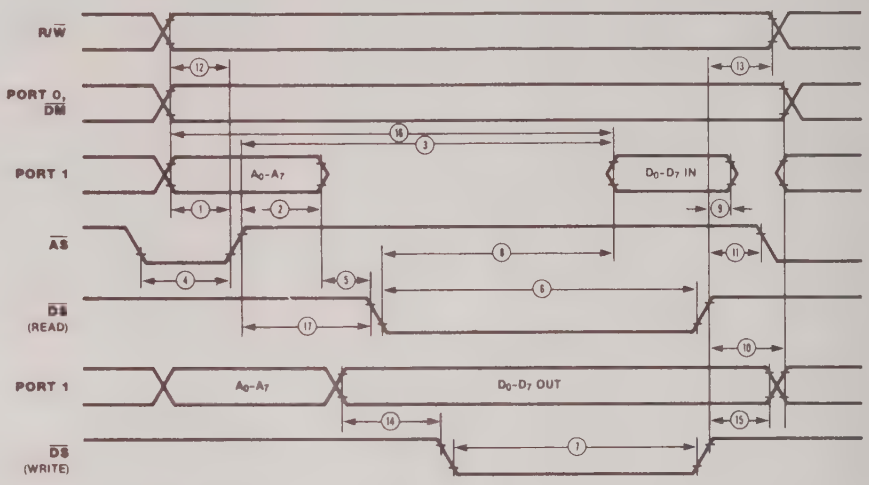
5-32. Keyboard/Display Control

Keyboard Display Controller U212 communicates with the In-Guard μC over the internal bus. During a μC write cycle, address line A0 tells U212 whether to consider data being sent by the μC as configuration commands or as display data. Display data is stored in the Keyboard Display Controller, which automatically scans the display. The Keyboard Display Controller selects one of eight grids using decoder U213 and buffer U215. The numeric display data is decoded from BCD to 7-segment by decoder U216 and buffered by U217. Additional annunciator data is buffered by U218.

The Keyboard Display Controller is reset by the μC whenever the μC is reset. It receives a 1-MHz clock signal from the custom A/D IC (U101), which uses the μC 8 MHz crystal for its clock input.

The Keyboard Display Controller scans the keyboard, sensing pressed buttons on lines RL0-RL7. It sends an interrupt to the μC via line KEYINT whenever a front panel button is pressed. The μC then reads the keycode from the Keyboard Display Controller. (The status of the FRONT/REAR switch is sensed separately by line F/R SENSE.)

External I/O or Memory Read and Write Timing



No.	Symbol	Parameter	Z8681/82 8 MHz Min	Max	Notes*†
1	TdA(AS)	Address Valid to $\overline{AS}$ ↑ Delay	50		1,2,3
2	TdAS(A)	$\overline{AS}$ ↑ to Address Float Delay	70		1,2,3
3	TdAS(DR)	$\overline{AS}$ ↑ to Read Data Required Valid		360	1,2,3,4
4	TwAS	$\overline{AS}$ Low Width	80		1,2,3
5	TdAz(DS)	Address Float to $\overline{DS}$ ↓	0		1
6	TwDSR	$\overline{DS}$ (Read) Low Width	250		1,2,3,4
7	TwDSW	$\overline{DS}$ (Write) Low Width	160		1,2,3,4
8	TdDSR(DR)	$\overline{DS}$ ↓ to Read Data Required Valid		200	1,2,3,4
9	ThDR(DS)	Read Data to $\overline{DS}$ ↑ Hold Time	0		1
10	TdDS(A)	$\overline{DS}$ ↑ to Address Active Delay	70		1,2,3
11	TdDS(AS)	$\overline{DS}$ ↑ to $\overline{AS}$ ↓ Delay	70		1,2,3
12	TdR/W(AS)	R/$\overline{W}$ Valid to $\overline{AS}$ ↑ Delay	50		1,2,3
13	TdDS(R/W)	$\overline{DS}$ ↑ to R/$\overline{W}$ Not Valid	60		1,2,3
14	TdDW(DSW)	Write Data Valid to $\overline{DS}$ (Write) ↓ Delay	50		1,2,3
15	TdDS(DW)	$\overline{DS}$ ↑ to Write Data Not Valid Delay	70		1,2,3
16	TdA(DR)	Address Valid to Read Data Required Valid		410	1,2,3,4
17	TdAS(DS)	$\overline{AS}$ ↑ to $\overline{DS}$ ↓ Delay	80		1,2,3

NOTES:
1. Test Load 1
2. Timing numbers given are for minimum TpC.
3. Also see clock cycle time dependent characteristics table.
4. When using extended memory timing add 2 TpC.
5. All timing references use 2.0 V for a logic "1" and 0.8 V for a logic "0".

* All units in nanoseconds (ns).
† Timings are preliminary and subject to change.

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Figure 5-14. Read/Write Timing Diagrams for Internal Bus

5-33. Troubleshooting Modes

In addition to running the diagnostic self-tests, the In-Guard μC has a troubleshooting mode which aids in finding digital hardware problems. After the μC is reset, it senses the relay control lines (U202-35 through U202-38) as inputs. If line U202-38 (TP205) is shorted to ground, the μC goes into the troubleshooting mode. (U201 provides internal pull-up.) The troubleshooting mode is described in detail in the Maintenance section.

5-34. Guard-Crossing Communication

The In-Guard μC contains a UART (universal asynchronous receiver transmitter) which it uses to communicate across the guard to the IEEE-488 Interface. The transmission speed is 62,500 bits per second.

5-35 GUARD CROSSING

The Guard Crossing consists of two identical circuits, each of which transmits data in one direction across the guard isolation between the Main Printed Circuit Assembly and the IEEE-488 Interface. One circuit is shown in Figure 5-15; the other circuit works identically. A portion of each circuit is contained in the IEEE-488 Interface.

The circuit in Figure 5-15 has two stable states, corresponding to output high (+5V) and output low (0V). If the output is high, the voltage present at the non-inverting input of op amp A is approximately +140 mV.

Since the inputs to op amps A and B are inverted, their outputs are always in opposite states. If the output of A is high, the output of B is low, forcing the inverting input of A (and the non-inverting input of B) to ground, hence reinforcing the existing state. The situation is analogous if the output of A is low.

A positive-going transition at the input causes a positive pulse at the non-inverting input of A, and a corresponding negative pulse at the inverting input of A. If the output is high to start with (with the non-inverting input of A raised 140 mV above its inverting input), these pulses reinforce the existing state (raising the non-inverting input and lowering the inverting input). If, however, the output is low to start with, the positive pulse (which is greater than 140 mV) raises the non-inverting input of A above its inverting input, switching the output to the high state. The situation is analogous for a negative-going input transition.

5-36. POWER SUPPLY

The Power Supply provides the following in-guard outputs: ±30V, ±15V, –6.2V, +7.5V, +5V, –5V, and –8.2V dc; and 4.5V ac. The Power Supply also provides a 16V ac center-tapped out-guard output.

Table 5-1. Sample Rates and Reading Rates

POWER LINE FREQUENCY	SLOW		MEDIUM		FAST	
	Samples per Sec	Samples per Reading	Samples per Sec	Samples per Reading	Samples per Sec	Samples per Reading
50 Hz	66.67	32	66.67	4	100	1
60 Hz	80	32	80	4	100	1
400 Hz	76.19	32	76.19	4	100	1

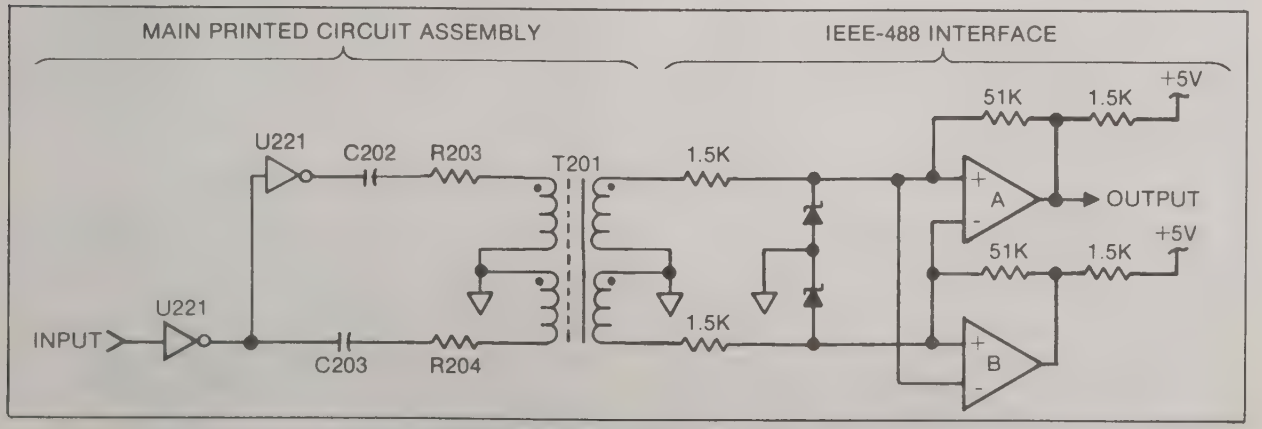


Figure 5-15. Guard Crossing Circuit

Input line voltage is directed to the primary transformer winding through fuse F601, the front panel POWER switch, and the rear panel LINE SET switches. Metal oxide varistor RV601 clamps line transients at about 390V. The LINE SET switches configure the Power Supply to accept line power of 100, 120, 220, or 240V ac (±10% with a maximum of 250V) at 50, 60, or 400 Hz.

AC voltage for the +5V supply is rectified by CR601 and CR602 and regulated by VR601. The +5V output supplies mostly logic circuits. The ac input to the +5V supply is sensed by the In-Guard μC (via R604, CR615, and U221-12,13) to measure the line frequency.

AC voltage for the +30V and –30V supplies is rectified by bridge network CR603, CR604, CR605, and CR606 and regulated by VR602 and VR605. The +30V and –30V outputs supply front-end buffer amp U306. In addition, the +30V output supplies the anodes of the vacuum fluorescent display. Zener diode CR612 supplies –6.2V to the A/D Converter clamps.

AC voltage for the +15V and –15V supplies is rectified by bridge network CR608, CR609, CR610, and CR611 and regulated by VR603 and VR604. The +15V and -15V supply analog circuitry throughout the 8840A. Zener diodes CR613 and CR614 supply +7.5V and –8.2V to the A/D Converter, analog filter, and DC Scaling circuit.

Secondary T601-14,15,16 supplies the vacuum fluorescent display filament with 4.5V ac. The center tap is connected to the in-guard +5V supply in order to correctly bias the display. An isolated secondary supplies 16V ac to the power supply on the IEEE-488 Interface.

Zener diode CR615 and SCR Q601 comprise a protective crowbar circuit. If the line voltage exceeds the nominal value by approximately 30 percent or more, CR615 conducts, turning on Q601, shorting out the power transformer secondary and blowing the line fuse. In normal operation, these components have no effect.

5-37. IEEE-488 INTERFACE (OPTION -05)

The IEEE-488 Interface has five major parts, as shown in the block diagram in Figure 5-16. All components are contained in a single printed circuit assembly (PCA). Reference designations are numbered in the 900 series.

5-38. Out-Guard Microcomputer

The Out-Guard Microcomputer (μC) (U901) performs all of the functions necessary to communicate with the IEEE-488 bus: handshaking, checking of syntax, interpretation of device-dependent commands, generation of error messages, etc. The Out-Guard μC also communicates with the In-Guard μC (U202) over the guard crossing.

The Out-Guard μC is identical to the In-Guard Z8 μC except for the contents of the internal ROM. For further description of the Z8 μC, refer to the heading "In-Guard Microcomputer," above.

5-39. Guard Crossing

The guard crossing circuit permits serial asynchronous communication between U901 and U202 while isolating the two electrically. One-half of the guard crossing circuit is contained on the Main PCA; the other half is on the IEEE-488 Interface PCA. Operation of the guard crossing circuit is described in an earlier heading.

5-40. Bus Transceiver

Bus transceivers U902 and U903 buffer U901 from the IEEE-488 bus. They provide the bus with the required output drive capability and receiver impedance. While ATN is true, the Out-Guard μC controls U905-9 to configure U902 and U903 either as bus drivers or receivers depending on whether the 8840A is addressed as a talker or a listener. (U905-9 is high when driving and low when receiving.) When ATN goes true, gates U904-3,-6 configure U902 and U903 as receivers in order to meet the IEEE-488 requirement that the 8840A stop driving the bus within 200 ns.

5-41. Signal Conditioning

The SAMPLE COMPLETE and EXT TRIG signals (J903 and J904) are conditioned by U906. Diodes CR903, CR904, CR905, and CR906 and resistors R917 and R918 provide protection from excessive voltages. Jumpers E902 and E903 allow selection of the polarity of the EXT TRIG signal. (A polarity selection procedure is given in the Maintenance section.) The 8840A is configured in the factory so that it is triggered on the falling edge of the EXT TRIG signal.

5-42. IEEE-488 Interface Power Supply

The IEEE-488 Interface power supply circuit provides the IEEE-488 Interface PCA with +5V. The circuit consists of rectifying diodes CR908 and CR909, filter capacitor C910, and voltage regulator VR901. Power comes from transformer T605 on the Main PCA. U908 and associated circuitry resets the Out-Guard μC at power-up and following power-line voltage dropouts.

5-43. TRUE RMS AC (OPTION -09)

The True RMS AC circuit (Figure 5-17) performs two primary functions. First, it scales ac input voltages and ac current sense voltages to a range of 0V to 2V ac rms. Second, it converts the scaled ac voltages to an equivalent dc voltage which is then directed to the A/D Converter via the Track/Hold Amplifier. The True RMS AC circuit is trimmed for flat high-frequency response using a variable filter which is set by the High-Frequency AC Calibration procedure.

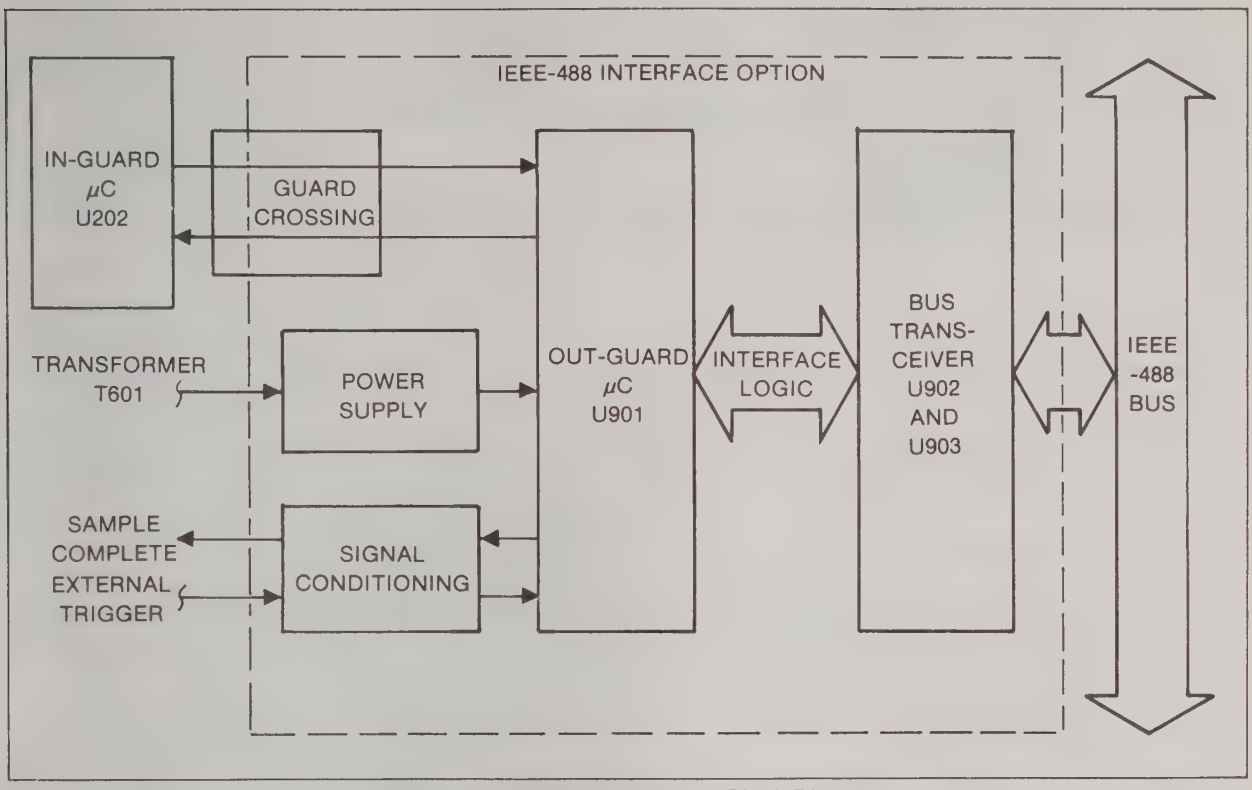


Figure 5-16. IEEE-488 Interface Block Diagram

The following paragraphs describe how these functions are performed. Components are laid out on a single printed circuit assembly (PCA). Component reference designators are numbered in the 800 series.

5-44. VAC Scaling

AC voltage inputs are directed from the HI INPUT terminal to the True RMS AC PCA through protection resistor R309 on the Main PCA. In this way, voltage transients greater than 1560V are clamped by MOVs (RV301, RV402, RV403, and RV404) as in the VDC function. With the VAC function selected, K801 is closed. The input voltage is thus applied to C801, which blocks dc inputs.

U807 and resistor network Z801 provide selectable attenuation and 1 MΩ input impedance. In the upper two ranges, K802 is closed and Q806 is off, providing a gain of −1/500. In the lower three ranges, K802 is open and Q806 is on, shorting Z801-4 to ground; this configuration provides a gain of −1/5. CR801 and CR802 provide protection by clamping the inverting input of U807 to approximately ±0.6V. Q805 shifts logic levels to control Q806.

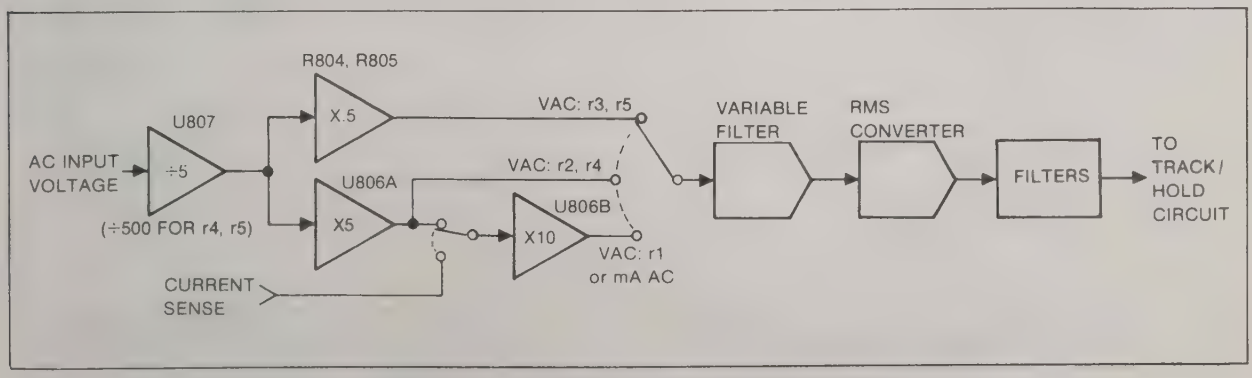


Figure 5-17. True RMS AC Option Block Diagram

U806A, U806B, and a voltage divider (R804 and R805) provide gain which is selected for each range by the analog switches in U804. The configuration for each range is shown in Figure 5-17. (In this figure, the CMOS analog switches are represented by mechanical switches.) When U806A is not used, its non-inverting input is grounded by Q804. When U806B is not used, its non-inverting input is connected to the CURRENT SENSE line.

5-45. mA AC Scaling

The mA AC function uses the same current shunt and protection network which is used for dc current. In the mA AC function, Q802 switches the CURRENT SENSE line to the non-inverting input of U806B, which provides a gain of 10.

5-46. Frequency Response Trimming

The frequency response is trimmed by software calibration using a digitally controlled one-pole low-pass filter (R832 and a combination of C826, C827, C828, and C829). The analog switches in U808 configure the four capacitors to select one of 16 possible RC constants. The input of the digitally controlled filter is buffered by voltage follower U801A. The individual gain stages are also provided with fixed frequency compensation.

5-47. True RMS AC-to-DC Conversion

U801B buffers the input to rms converter U802. U802 computes the rms value of the scaled input voltage as shown in Figure 5-18. Rather than explicitly squaring and averaging the input, U802 uses an implicit method in which feedback is used to perform an equivalent analog computation.

The filter averages the divider output signal. This filter consists of U809A, C813, R815, and the internal 25 kΩ resistor and op amp between pins 8 and 9 of U802. The output is further filtered by a three-pole post-filter comprised of U809B and associated resistors and capacitors. This output is then switched into the Track Hold Amplifier of the dc front end via U302 pins 15 and 14. The Track/Hold Amplifier is set up for unity gain on all ac ranges.

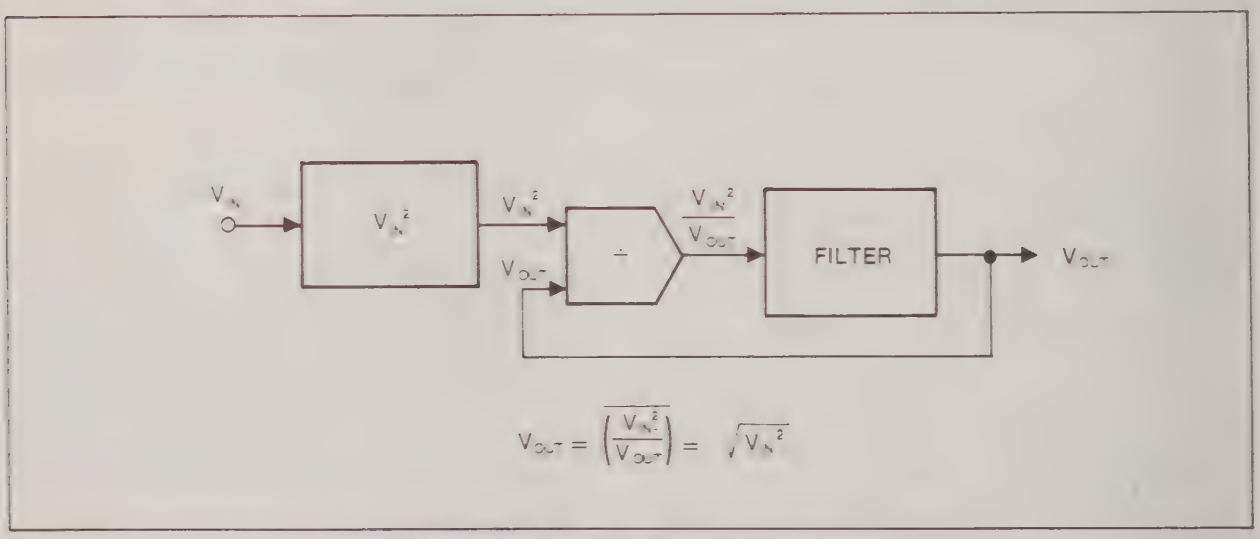


Figure 5-18. True RMS AC-to-DC Converter

static awareness

A Message From

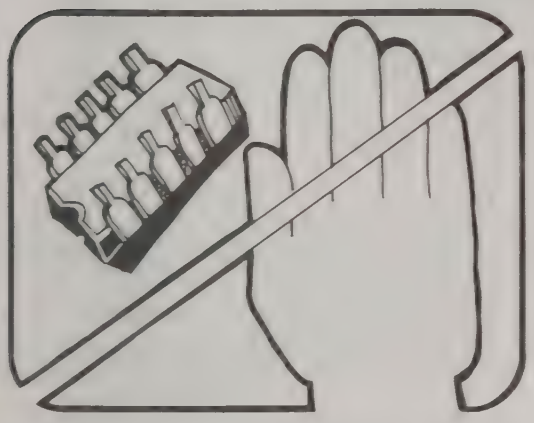
John Fluke Mfg. Co., Inc.

Some semiconductors and custom IC's can be damaged by electrostatic discharge during handling. This notice explains how you can minimize the chances of destroying such devices by:

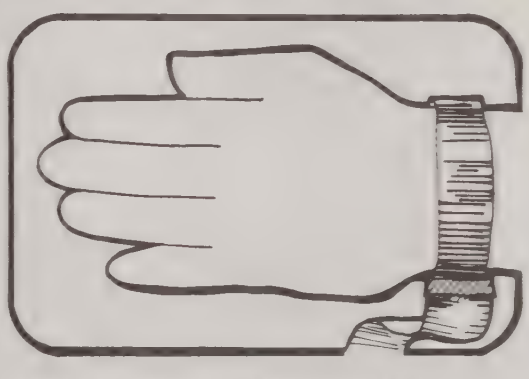
1. Knowing that there is a problem.
2. Learning the guidelines for handling them.
3. Using the procedures, and packaging and bench techniques that are recommended.

The Static Sensitive (S.S.) devices are identified in the Fluke technical manual parts list with the symbol "⊗"

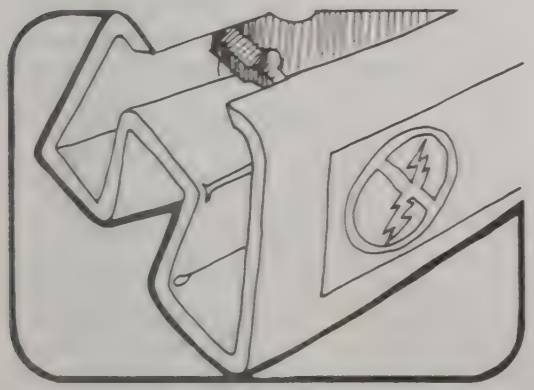
The following practices should be followed to minimize damage to S.S. devices.



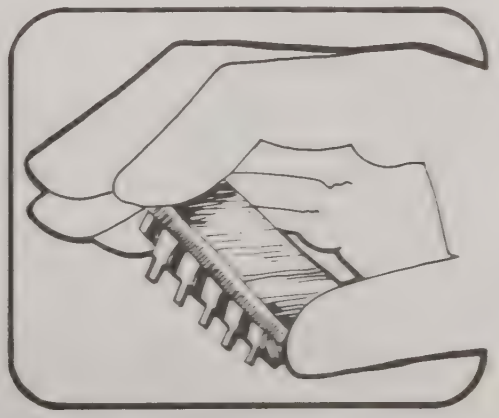
1. MINIMIZE HANDLING



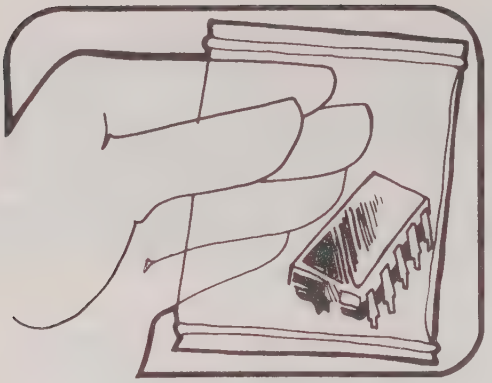
3. DISCHARGE PERSONAL STATIC BEFORE HANDLING DEVICES



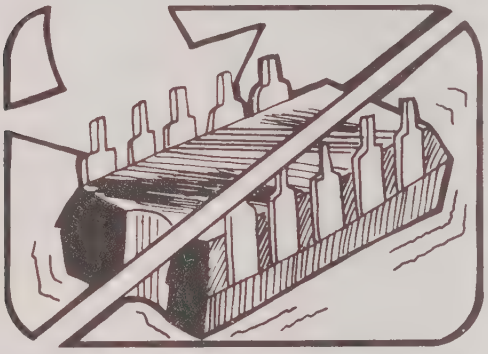
2. KEEP PARTS IN ORIGINAL CONTAINERS UNTIL READY FOR USE.



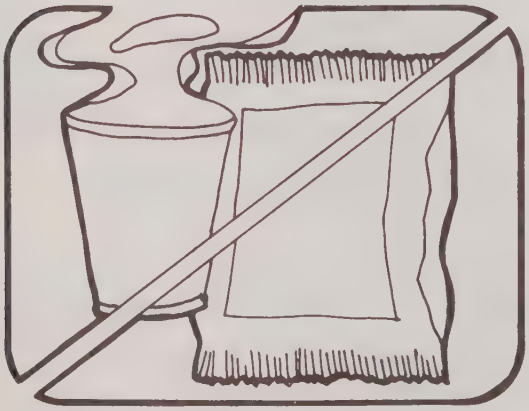
4. HANDLE S.S. DEVICES BY THE BODY



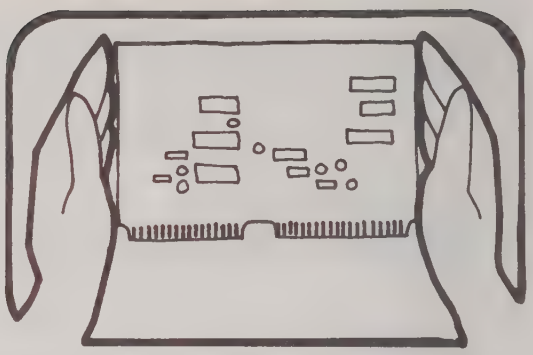
5. USE ANTI-STATIC CONTAINERS FOR HANDLING AND TRANSPORT



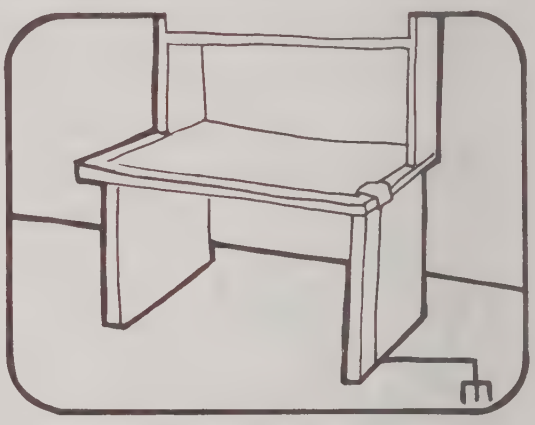
6. DO NOT SLIDE S.S. DEVICES OVER ANY SURFACE



7. AVOID PLASTIC, VINYL AND STYROFOAM® IN WORK AREA



8. WHEN REMOVING PLUG-IN ASSEMBLIES, HANDLE ONLY BY NON-CONDUCTIVE EDGES AND NEVER TOUCH OPEN EDGE CONNECTOR EXCEPT AT STATIC-FREE WORK STATION. PLACING SHORTING STRIPS ON EDGE CONNECTOR USUALLY PROVIDES COMPLETE PROTECTION TO INSTALLED SS DEVICES.



9. HANDLE S.S. DEVICES ONLY AT A STATIC-FREE WORK STATION
10. ONLY ANTI-STATIC TYPE SOLDER-SUCKERS SHOULD BE USED.
11. ONLY GROUNDED TIP SOLDERING IRONS SHOULD BE USED.

Anti-static bags, for storing S.S. devices or pcbs with these devices on them, can be ordered from the John Fluke Mfg. Co., Inc.. See section 5 in any Fluke technical manual for ordering instructions. Use the following part numbers when ordering these special bags.

John Fluke Part No.	Description
453522	6" X 8" Bag
453530	8" X 12" Bag
453548	16" X 24" Bag
454025	12" X 15" Bag
Pink Poly Sheet	Wrist Strap
30"x60"x60 Mil	P/N TL6-60
P/N RC-AS-1200	$7.00
$20.00	

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Section 6
Maintenance

WARNING

THESE SERVICE INSTRUCTIONS ARE FOR USE BY QUALIFIED PERSONNEL ONLY. TO AVOID ELECTRIC SHOCK, DO NOT PERFORM ANY PROCEDURES IN THIS SECTION UNLESS YOU ARE QUALIFIED TO DO SO.

6-1. INTRODUCTION

This section presents maintenance information for the 8840A. The section includes a performance test, a calibration procedure, troubleshooting information, and other general service information.

Test equipment recommended for the performance test and calibration procedure is listed in Table 6-1. If the recommended equipment is not available, equipment that meets the indicated minimum specifications may be substituted.

6-2. PERFORMANCE TEST

This test compares the performance of the 8840A with the specifications given in Section 1. The test is recommended as an acceptance test when the instrument is first received, and as a verification test after performing the calibration procedure. If the instrument does not meet the performance test, calibration or repair is needed.

To ensure optimum performance, the test must be performed at an ambient temperature of 18°C to 28°C, with a relative humidity of less than 75%. Also, the 8840A should be allowed to warm up for one hour prior to beginning any test other than the self-test.

6-3. Diagnostic Self-Tests

The diagnostic self-tests check the analog and digital circuitry in the 8840A. There are 21 analog tests followed by in-guard program memory, calibration memory, and display tests. Out-guard program memory is tested when self-test is initiated by a remote command. Microcomputer RAM tests are done only at powerup.

Each test is described in detail under the heading Troubleshooting. All five digital tests are performed at powerup.

NOTE

The inputs must be left open-circuited while the self-tests are performed. Otherwise, the 8840A may indicate errors are present. Errors may also be caused by inductive or capacitive pick-up from long test leads.

If the FRONT/REAR switch is in the REAR position, the 8840A skips tests 3 and 4. Also, if Option -09 is not installed, the 8840A skips tests 1, 2, and 3.

To initiate the self-tests, press the SRQ button for 3 seconds. The TEST annunciator will then light up, and the 8840A will run through the analog tests in sequence. Each test number is displayed for about 1 second. The instrument can be stopped in any of the test configurations by pressing the SRQ button while the test number is displayed. Pressing any button continues the tests.

After the last analog test is performed, all display segments light up while the instrument performs the in-guard program memory, calibration memory, and display tests. The instrument then assumes the power-up configuration: VDC, autorange, slow reading rate, offset off, local control.

If the 8840A detects an error during one of the tests, it displays the ERROR annunciator and the test number for about 2-1/2 seconds, and then proceeds to the next test. The test number thus becomes an error code. (Error codes are listed in Table 2-1, Section 2.)

Passing all diagnostic self-tests does not necessarily mean the 8840A is 100% functional. The test, for example,

Table 6-1. Recommended Test Equipment

INSTRUMENT TYPE	MINIMUM SPECIFICATIONS	RECOMMENDED MODEL
DC Calibrator	PREFERRED: Voltage Range: 0-1000V dc Voltage Accuracy: 10 ppm Absolute Linearity: ±1.0 ppm	Fluke 5440A
	ALTERNATIVE: (Must be used with Kelvin-Varley Voltage Divider) Voltage Range: 0-1000V dc Voltage Accuracy: 20 ppm + 20 ppm of range	Fluke 343A
	Kelvin-Varley Voltage Divider: Ratio Range: 0-1.0 Absolute Linearity: ±1 ppm of input at dial setting	Fluke 720A
Resistance Calibrator	Resistance Accuracy: 0.005%	Fluke 5450A, ESI DB62
DC Current Source	Accuracy: ±0.025%	Fluke 5100B or Fluke 382
Oscilloscope	General purpose, 60 MHz, with 10 MΩ probe	Tektronix 2213, 2215, 465A, 465B, or 475
Digital Multimeter	Voltage Accuracy: 0.01% in V dc 1.0% for 1V in V ac @ 100 kHz Input Impedance: 10 MΩ or greater in V dc: 1 MΩ or greater in parallel with <100 pF in V ac	Fluke 8840A (with AC Option -09), Fluke 8860A, or Fluke 8810A (with AC Option -08 or -09)
AC Calibrator		Fluke 5200A and Fluke 5205A

Minimum Required Accuracy (By Range)

Frequency Range	1, 10, 100 mV[1]	1, 10, 100V[2]	1000V[2]
20 Hz-30 Hz	1 – 005	1 – 005	12 – 005
30 Hz-20 kHz	02 – 10	02 - 002	.04 – 004
20 kHz-50 kHz	05 – 20	05 - 005	08 – 005
50 kHz-100 kHz	05 – 20	05 – 005	1 – 01

1. ±(% of setting + μV 2. ±(% of setting + % of range)

AC Current Source		Fluke 5100A or Fluke 5220A

Frequency Range	Minimum Required Accuracy (All Ranges)
30 Hz-1 kHz	±(.07% + 1 mA)
1 kHz-5 kHz	±(.07% + 1 mA) X frequency in kHz

Shorting Bar	Resistance: <1.5 mΩ Construction: Soldered (not rivetted)	Pomona MDP-S-0
6-Inch Jumper	--	E-Z-Hook 204-6W-S or equivalent
Optional Test Equipment	9010A, 9005A or Micro-System Troubleshooter: 9000A-8048 Interface Pod: 8840A-9000 Troubleshooting Kit (see para. 8-13).	

cannot check the accuracy of the analog circuitry. If one or more errors are displayed, the 8840A probably requires service.

6-4. DC Voltage Test

The following procedure may be used to verify the accuracy of the VDC function:

1. Ensure the 8840A is on and has warmed up for at least 1 hour.
2. Select the VDC function.
3. Connect the DC Calibrator (see Table 6-1) to provide a voltage input to the HI and LO

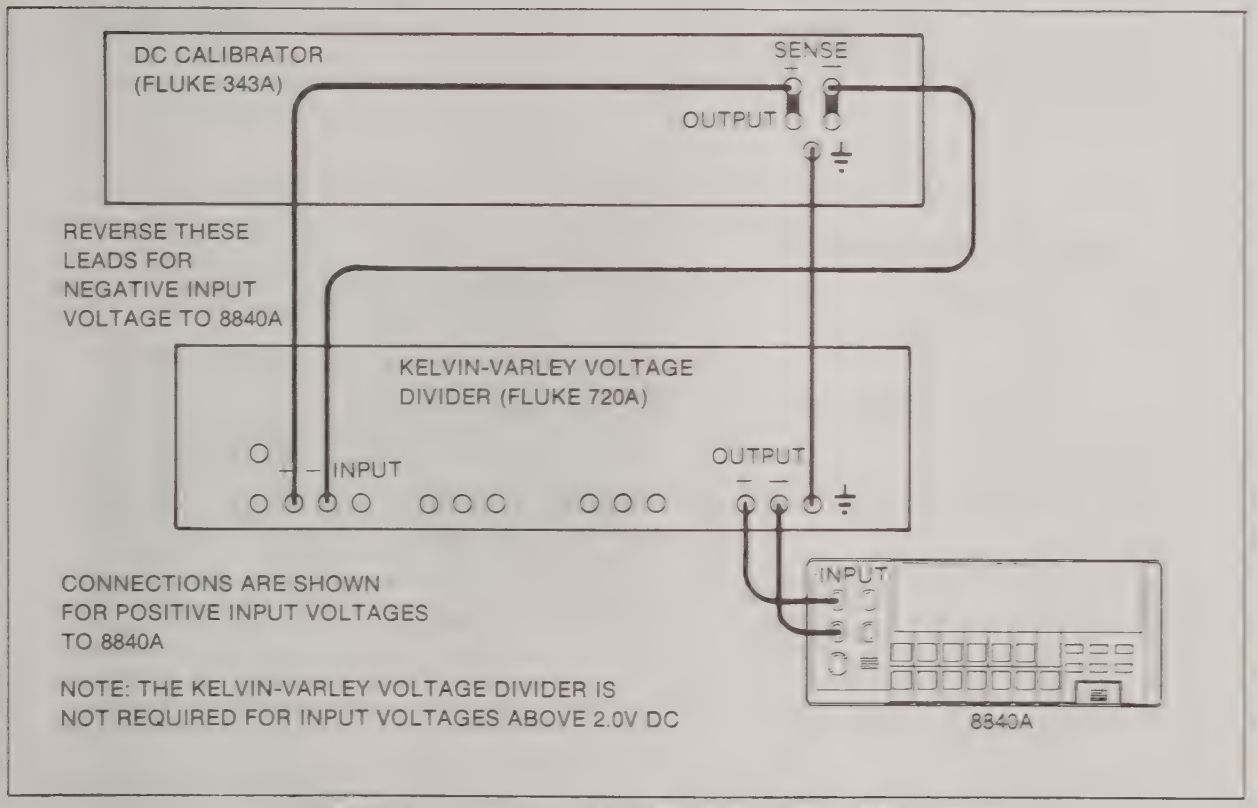


Figure 6-1. Connections for Kelvin-Varley Voltage Divider

Table 6-2. DC Voltage Test

STEP	RANGE	INPUT (V dc)	DISPLAYED READING					
			SLOW		MEDIUM		FAST	
			MINIMUM	MAXIMUM	MINIMUM	MAXIMUM	MINIMUM	MAXIMUM
A[1]	200 mV	0V (short)	-00.003	+00.003	-00.005	+00.005	-00.02	+00.02
B	2V, 20V, 200V, 1000V	0V (short)	-3 counts	+3 counts	-5 counts	+5 counts	-2 counts	+2 counts
C[1]	200 mV	100 mV	+99.989	+100.011	+99.987	+100.013	+99.97	+100.03
D	2V	1V	+.99993	+1.00007	+.99991	+1.00009	+.9997	+1.0003
E	20V	10V	+9.9992	+1.00008	+9.9990	+10.0010	+9.997	+10.003
F	200V	100V	+99.992	+100.008	+99.990	+100.010	+99.97	+100.03
G	1000V	1000V	+999.92	+1000.08	+999.90	+1000.10	+999.7	+1000.3

1. Relative to high-quality short stored using OFFSET feature.

INPUT terminals. If using the Fluke 343A and the Kelvin-Varley Voltage Divider instead of the Fluke 5440A, connect the test leads as shown in Figure 6-1.

4. For each step in Table 6-2, select the indicated range, set the DC Calibrator for the specified input, and verify that the displayed reading is within the limits shown for each reading rate. (For step A, connect a short across the HI and LO INPUT terminals and press OFFSET. The measurement in step C should be relative to this offset.)

5. Set the DC Calibrator for zero volts and disconnect it from the 8840A.

6-5. AC Voltage Test (Option -09 Only)

The following procedure may be used to verify the accuracy of the VAC function:

1. Ensure the 8840A is on and warmed up for at least 1 hour.

2. Select the VAC function and the slow (S) reading rate.

3. Connect the AC Calibrator to provide a voltage input to the HI and LO INPUT terminals.

4. (Low- and Mid-Frequency Test.) For each step in Table 6-3, select the indicated range, set the AC Calibrator for the specified input, and verify that the displayed reading is within the limits shown for each reading rate.

NOTE

This procedure tests the extremes of each range. You may shorten the procedure by testing only the "quick test points" indicated in Table 6-3 with asterisks.

Table 6-3. Low- and Mid-Frequency AC Voltage Test

STEP NUMBER	RANGE	INPUT		ERROR IN COUNTS	TEST LIMITS (IN VOLTS)	
		VOLTAGE	FREQUENCY		MINIMUM	MAXIMUM
1	2V	0.01000V	100 Hz	201	0.00799	0.01201
2	2V	0.10000V	100 Hz	114	0.09886	0.10114
3*	2V	0.30000V	100 Hz	142	0.29858	0.30142
4	2V	1.00000V	100 Hz	240	0.99760	1.00240
5*	2V	1.90000V	100 Hz	366	1.89634	1.90366
6	2V	0.10000V	20 Hz	220	0.09780	0.10220
7	2V	1.90000V	20 Hz	2380	1.87620	1.92380
8	2V	0.10000V	45 Hz	135	0.09865	0.10135
9	2V	1.90000V	45 Hz	765	1.89235	1.90765
10 *	200 mV	0.001000V	100 Hz	201	0.000799	0.001201
11	200 mV	0.190000V	20 kHz	366	0.189634	0.190366

*Quick test points.

Table 6-4. High-Frequency AC Voltage Test

STEP NUMBER	RANGE	INPUT		ERROR IN COUNTS	TEST LIMITS (IN VOLTS)	
		VOLTAGE	FREQUENCY		MINIMUM	MAXIMUM
1	200 mV	0.010000V	50 kHz	169	0.009831	0.010169
2*	200 mV	0.010000V	100 kHz	350	0.009650	0.010350
3*	2V	0.10000V	100 kHz	350	0.09650	0.10350
4*	20V	1.0000V	100 kHz	350	0.9650	1.0350
5*	200V	10.000V	100 kHz	350	9.650	10.350
6*	700V	100.00V	100 kHz	350	96.50	103.50
7	20V	19.0000V	100 kHz	1250	18.8750	19.1250
8	200 mV	0.190000V	100 kHz	1250	0.188750	0.191250

*Quick test points.

5. (High-Frequency Test.) For each step in Table 6-4, select the indicated range, set the AC Calibrator for the specified input, and verify that the displayed reading is within the limits shown for each reading rate.

NOTE

This procedure tests the extremes of each range. You may shorten the procedure by testing only the "quick test points" indicated in Table 6-4 with asterisks.

6. Set the AC calibrator to standby and disconnect it from the 8840A.

6-6. Resistance Test

The following procedure may be used to verify the accuracy of the 2-wire and 4-wire ohms functions.

1. Ensure the 8840A is on and has warmed up for at least 1 hour.

2. Connect the Resistance Calibrator to the 8840A for 4-wire ohms.

3. For each step in Table 6-5, select the indicated range, set the Resistance Calibrator for the specified nominal input, and proceed as follows:

   A. Test the 4-wire ohms function:

      1. Select the 4-wire ohms function.

      2. Verify that the displayed reading is within the limits shown for each reading rate.

Table 6-5. Resistance Test

STEP	RANGE	INPUT (Nominal)	ERROR FROM INPUT (In Counts)		
			SLOW	MEDIUM	FAST
1	200Ω	0Ω (short)	±4	±6	±3
2	2 kΩ	0Ω (short)	±3	±5	±2
3	20 kΩ	0Ω (short)	±3	±5	±2
4	200 kΩ	0Ω (short)	±3	±5	±2
5	2000 kΩ	0Ω (short)	±3	±6	±2
6	20 MΩ	0Ω (short)	±3	±6	±2
7	200Ω	100Ω	±15	±17	±4
8	2 kΩ	1 kΩ	±13	±15	±3
9	20 kΩ	10 kΩ	±13	±15	±3
10	200 kΩ	100 kΩ	±13	±15	±3
11	2000 kΩ	1 MΩ	±30	±33	±5
12	20 MΩ	10 MΩ	±47	±50	±6

   B. Test the 2-wire ohms function:

1. Select the 2-wire ohms function. (The SENSE test leads need not be disconnected.)

2. Zero the test lead resistance by pressing the OFFSET switch while shorting the HI and LO INPUT test leads together.

3. Verify that the displayed reading is within the limits shown for each reading rate.

6-7. DC Current Test

The following procedure may be used to test the mA DC function:

1. Ensure the 8840A is on and has warmed up for at least 1 hour.

2. Select the mA DC function.

3. Connect the Current Source to the 2A and LO INPUT terminals.

4. For each step in Table 6-6, set the Current Source for the indicated input and verify that the displayed reading is within the limits shown for each reading rate.

5. Set the Current Source for zero mA and disconnect it from the 8840A.

6-8. AC Current Test (Option -09 Only)

The following procedure may be used to test the mA AC function:

1. Ensure the 8840A is on and warmed up for at least 1 hour.

2. Select the mA AC function.

3. Connect the AC Current Source to provide a current input to the 2A and LO INPUT terminals. If an ac current source is not available, the functionality of the 8840A can be checked at 10 mA by using a Fluke 5200A set at 100V and connected to the 8840A 2A terminal through a 10 kΩ, 2W, 1% resistor.

4. For each step in Table 6-7, set the AC Current Source for the indicated input and verify that the displayed reading is within the limits shown for each reading rate.

5. Set the AC Current Source to Standby and disconnect it from the 8840A.

6-9. CALIBRATION

CAUTION

To avoid uncalibrating the 8840A, never toggle power on or off while the CAL ENABLE switch is on.

The 8840A features closed-case calibration using known reference sources. The 8840A automatically prompts you for the required reference sources, measures them, calculates correction factors, and stores the correction factors in the nonvolatile calibration memory.

Closed-case calibration has many advantages. There are no parts to disassemble, no mechanical adjustments to make, and if the IEEE-488 Interface is installed, the 8840A can be calibrated by an automated instrumentation system.

The 8840A should normally be calibrated on a regular cycle, typically every 90 days or 1 year. The frequency of the calibration cycle depends on the accuracy specification you wish to maintain. The 8840A should also be calibrated if it fails the performance test or has undergone repair. To meet the specifications in Section 1, the 8840A should be calibrated with equipment meeting the minimum specifications given in Table 6-1.

The following paragraphs first present a basic calibration procedure. This is followed by a description of advanced features and special considerations, and by a description of remote calibration using the IEEE-488 Interface.

6-10. Basic Calibration Procedure

The basic calibration procedure consists of the following four parts. These parts must be performed in the order shown.

1. Initial Procedure.
2. A/D Calibration.
3. Offset and Gain Calibration for each function and range.
4. High-Frequency AC Calibration (True RMS AC option only).

Normally, it is recommended that the entire calibration procedure be performed. However, under some circumstances the earlier parts may be omitted. For example, if installing the True RMS AC option, it may be necessary only to perform Offset and Gain Calibration for the ac functions, followed by High-Frequency AC Calibration. But if the A/D Calibration is performed, it must be followed by a complete Offset and Gain Calibration for all functions and then by High-Frequency AC Calibration.

Table 6-6. DC Current Test

STEP NUMBER	INPUT	DISPLAYED READING					
		SLOW		MEDIUM		FAST	
		MINIMUM	MAXIMUM	MINIMUM	MAXIMUM	MINIMUM	MAXIMUM
1	0 mA	-000.04	−000.04	-000.06	−000.06	-000.2	−000.2
2	1000 mA dc	-999.56	−1000.44	-999.54	−1000.46	-999.4	−1000.6

Table 6-7. AC Current Test

STEP NUMBER	RANGE	INPUT		TEST LIMITS	
		CURRENT	FREQUENCY	MINIMUM	MAXIMUM
1	2000 mA	1900.00 mA	1 kHz	1890.40	1909.60
2	2000 mA	100.00 mA	1 kHz	97.60	102.40

Some of the calibration calculations are complex and take the 8840A some time to execute. For example, when you store the zero input during the Offset and Gain Calibration for the VDC function, it takes around 22 seconds before the next prompt appears. (The 8840A automatically uses this input to calibrate the offset for all ranges.) While the 8840A is executing a calibration step, it ignores all of the front panel buttons and postones execution of all remote commands.

6-11. INITIAL PROCEDURE

Always begin the calibration procedure as follows:

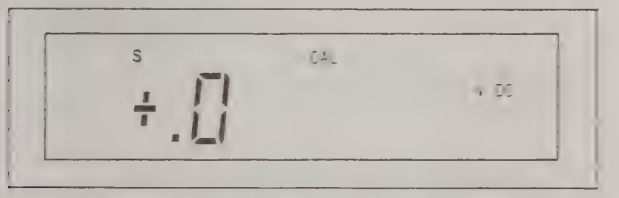


Figure 6-2. First A/D Calibration Prompt

1. Allow the 8840A to stabilize in an environment with ambient temperature of 18°C to 28°C and relative humidity less than 75%.
2. Turn the 8840A on and allow it to warm up for at least 1 hour.
3. Enable the calibration mode by pressing the CAL ENABLE switch with a small screwdriver or other suitable instrument. (The CAL ENABLE switch is located on the right side of the display and is normally covered by a calibration seal.)

When the calibration mode is enabled, the CAL annunciator lights up, and the 8840A displays the first prompt for the A/D Calibration procedure (Figure 6-2). To exit the calibration mode, press the CAL ENABLE switch again.

In the calibration mode, the front panel controls assume the functions described in Figure 6-3. Some of these

Function Buttons	Each button selects the Offset and Gain Calibration procedure for the respective function.
Range Buttons	These buttons have two functions. Normally, pressing a range button selects the Offset and Gain Calibration procedure for that range in the presently selected function. When using the variable input feature, these buttons are used to increment the digits of the displayed prompt. The range buttons are ignored during the A/D Calibration procedure.
STORE	Tells the 8840A that the input it is requesting is now present at the input terminals. Pressing the STORE button causes the 8840A to compute and store calibration constants.
A/D	Selects the A/D Calibration procedure.
HF AC	Selects the High-Frequency AC Calibration procedure.
ERASE	Used to erase calibration constants from calibration memory. To complete an erasure of all or part of calibration memory, you must press another button within 1½-seconds of pressing this button. CAUTION If any part of calibration memory is erased, all or part of the calibration procedure must be performed.
RATE	Changes the reading rate. Valid only when the 8840A is taking verification readings. Ignored at other times.
VAR IN	Allows the use of reference sources that differ from the prompted values. After pressing VAR IN (variable input), the range buttons can be used to change the displayed prompt. The variable input feature is not available during the A/D Calibration procedure.

Figure 6-3. Calibration Functions

functions are advanced features and are not required for the basic calibration procedure. The display blanks briefly when a button is pressed.

The following functions are inappropriate during calibration, and are therefore unavailable:

- Offset
- Autoranging
- External Trigger
- Front Panel Trigger
- Front panel SRQ (Under local control)
- Diagnostic self-tests

6-12. A/D CALIBRATION

The A/D Calibration procedure calibrates the analog-to-digital converter for offset, gain and linearity. The 8840A automatically selects the A/D calibration procedure when the CAL ENABLE switch is first pressed. The procedure must be performed in its entirety, and may not be performed in part. If the A/D calibration is discontinued prior to completion, the last complete set of A/D calibration constants will be retained unchanged.

To perform A/D Calibration, proceed as follows:

1. Ensure the Initial Procedure has been completed. The 8840A then displays the prompt for the first reference source, zero volts (i.e., a short).

2. Each time the 8840A prompts you for a reference source, apply the requested source to the HI and LO INPUT terminals, and press the STORE button. When STORE is pressed, the numeric display field blanks while the 8840A performs the necessary calculations. (Do not change the reference source while the display is blank.) The 8840A then displays the next prompt. For reference, all prompts are shown in Table 6-8.

NOTE

The 8840A automatically checks that the reference input is near the value prompted, and displays ERROR 41 if it exceeds a specific tolerance. (See Advanced Features and Special Considerations, later in this section.)

3. After the last input is stored, the 8840A begins taking readings in the 2V range of the VDC function. (The CAL annunciator remains on.) Verify the A/D calibration using the test points in Table 6-9. If you wish to repeat the A/D Calibration procedure, press the A/D button.

The A/D Calibration procedure is an iterative process. Each pass through the procedure uses the constants stored previously and improves them. Normally, one pass is adequate. However, if the calibration memory has been erased or replaced, or the A/D Converter has undergone repair, the A/D Calibration procedure must be performed twice.

Because the A/D Calibration procedure is iterative, the instrument's performance can be slightly enhanced by going through the procedure more than twice. However, this is not necessary to meet the published specifications.

Table 6-8. A/D Calibration Steps

STEP	DISPLAYED PROMPT
A	.0 V DC (short)
B	- .03 V DC
C	- 1.01 V DC
D	+ .99 V DC
E	+ .51 V DC
F	- .51 V DC
G	- .26 V DC
H	+ .26 V DC
I	+ .135 V DC
J	- .135 V DC
K	- .0725 V DC
L	+ .0725 V DC

Table 6-9. A/D Calibration Verification Test

STEP	INPUT	ALLOWABLE ERROR
A	0V (short)	±2 counts
B	-0.03V	±2 counts
C	+0.03V	±2 counts
D	-0.660V	±3 counts
E	+0.660V	±3 counts
F	-1.970V	±4 counts
G	+1.970V	±4 counts

6-13. OFFSET AND GAIN CALIBRATION

This procedure calibrates the instrument's offsets and gains by applying a high and low input for every range of each function. To save time, the 8840A uses each input for as many ranges as possible.

A function is calibrated by pressing the corresponding function button. Once a function is selected, the 8840A automatically steps through each range of that function, prompting you for the necessary reference sources. (The prompts are shown in Table 6-10.) The 8840A does not automatically select another function after one function has been completely calibrated; therefore, the functions may be calibrated in any order.

To perform Offset and Gain Calibration, proceed as follows:

1. Ensure the A/D Calibration procedure has been completed.

2. Select the desired function by pressing the corresponding function button. The 8840A will display the first prompt for that function.

3. Each time the 8840A prompts you for a reference source, apply this source to the appropriate terminals, and press the STORE button. When STORE is pressed, the numeric display field blanks while the 8840A performs the necessary calculations. (Do not change the reference source while the display is blank.) The 8840A then displays the next prompt. For reference, all prompts are shown in Table 6-10.

NOTE

To use reference sources that differ from the prompted values, see Storing Variable Inputs later in this section.

4. After the last range is calibrated, the 8840A begins taking readings in the highest range so that you may verify its calibration. (The CAL annunciator remains on.) To verify the calibration for the other ranges, press the corresponding range button. (Pressing a function button begins the Offset and Gain Calibration procedure for that function.)

5. Repeat steps 2, 3, and 4 for the remaining functions. Note that both 2-wire and 4-wire ohms functions must be calibrated. (The VAC and mA AC functions require calibration only if the True RMS AC option is installed.)

NOTE

(True RMS AC option only.) The VAC and mA AC functions should normally be calibrated using reference sources at 1 kHz (±10%). For special applications, performance may be optimized at other frequencies. See Optimizing AC Calibration at Other Frequencies, later in this section.

Table 6-10. Offset and Gain Calibration Steps

STEP	DISPLAYED PROMPT				
	VDC	VAC[1]	2 WIRE kΩ 4 WIRE kΩ	mA DC	mA AC[1]
A	+00.0 mV DC (short)	10.0 mV AC	0.00 Ω (short)	00.0 mA DC (open)	100. mA AC
B	+190.0 mV DC	100.0 mV AC	100.0 Ω	1000. mA DC	1000 mA AC
C	+1.900 V DC	1.000 V AC	1.000 kΩ	Steps C-G not applicable for these functions.	
D	+19.00 V DC	10.00 V AC	10.00 kΩ		
E	+190.0 V DC	100.0 V AC	100.0 kΩ		
F	+1000. V DC	500. V AC	1000. kΩ		
G	Step G not applicable for these functions.		10.00 MΩ		

1. Inputs should be at 1 kHz ±10%. Performance may be enhanced for specific frequencies (see text).

6. When all functions have been calibrated, exit the calibration mode by pressing the CAL ENABLE switch and attach a calibration certification sticker over the CAL ENABLE switch. (If the True RMS AC option is installed, instead proceed to the High-Frequency AC Calibration procedure which follows.)

6-14. HIGH-FREQUENCY AC CALIBRATION

The High-Frequency AC Calibration procedure calibrates the response of the VAC function from 20 kHz to 100 kHz. If the True RMS AC option is not installed, selecting this procedure results in an error message.

The reference sources used in this procedure should normally be between 90 kHz and 100 kHz. 100 kHz (nominal) is recommended. For special applications, performance may be optimized at other frequencies. See Optimizing AC Calibration at Other Frequencies, later in this section.

To perform High-Frequency AC Calibration, proceed as follows:

1. Ensure Offset and Gain Calibration has been completed for the VAC function.

2. Select the High-Frequency AC Calibration procedure by pressing the HF AC button. The 8840A will display the first prompt (100 mV AC). The "U" in the display indicates the High-Frequency AC Calibration procedure has been selected.

3. Each time the 8840A prompts you for a reference amplitude, apply this amplitude to the HI and LO INPUT terminals, and press the STORE button. When STORE is pressed, the numeric display field blanks while the 8840A performs the necessary calculations. (Do not change the reference source while the display is blank.) The 8840A then displays the next prompt. For reference, all prompts are shown in Table 6-11.

NOTE

To use reference amplitudes that differ from the prompted values, see Storing Variable Inputs later in this section.

4. After the last range is calibrated, the 8840A begins taking readings in the highest range so that you may verify its calibration. To verify the calibration for the other ranges, push the corresponding range button. The CAL annunciator remains on.

5. The calibration procedure is now completed. Exit the calibration mode by pressing the CAL ENABLE switch, and attach a calibration certification sticker over the CAL ENABLE switch.

6-15. Advanced Features and Special Considerations

The 8840A has several advanced calibration features which are not necessary for the basic calibration procedure, but which can make calibration easier. The following paragraphs describe these features and also discuss special considerations for optimizing the performance of the 8840A in special situations.

6-16. STORING VARIABLE INPUTS

As a convenience, the VAR IN (variable input) feature lets you calibrate the 8840A using reference source values which differ from the values prompted by the 8840A. For example, you may want to calibrate the 200Ω range using a reference resistor with a precisely known value of 99.875Ω, rather than 100Ω as prompted. This feature is not available during A/D Calibration.

To use the variable input feature, proceed as follows:

1. When the 8840A prompts you for an input, press the VAR IN button. The blank digits will be replaced with zeroes. You can then increment each digit of the display by pressing the range buttons. The 200Ω/mV button toggles the displayed sign.

2. Change the displayed prompt to correspond to the desired reference source by pressing the appropriate range buttons.

3. Connect the desired reference source to the appropriate input terminals of the 8840A.

Table 6-11. High-Frequency AC Calibration Steps

STEP	DISPLAYED PROMPT[1,2]
A	100.0 mV AC
B	1.000 V AC
C	10.00 V AC
D	100.0 V AC
E	200.0 V AC

NOTES:

1. The display also indicates "U" to show that HF AC cal is selected.

2. Inputs should be between 90 kHz and 100 kHz. 100 kHz (nominal) is recommended.

4. Press the STORE button.

To meet the specifications over all ranges, the reference source for the high prompts must be between half and full scale. (The high prompts are those prompts that are between 50% and 100% of full scale.) The reference source for the low prompts must be equal to or greater than the prompted value, but not more than that value plus 4000 counts. (The low prompts are those prompts that are zero or 5% of full scale.)

For special applications, the 8840A can be calibrated at values outside the recommended range. This can enhance the performance at the calibration value. However, performance at other values may be degraded.

6-17. CALIBRATING INDIVIDUAL RANGES

During Offset and Gain and High-Frequency AC Calibration, it is possible to calibrate individually selected ranges. This feature does not apply to the mA DC and mA AC functions and is not permitted during A/D Calibration.

To calibrate an individual range, proceed as follows:

1. Select the desired calibration procedure by pressing the appropriate function button (or press the HF AC button if High-Frequency AC Calibration is desired).

2. Press the range button for the range to be calibrated. The 8840A then prompts for a low reference source for that range. (See Table 6-12.) (During High-Frequency AC Calibration, the 8840A prompts only for a high reference source. In this case, proceed to step 4.)

3. Apply the requested reference source and press STORE. The display will blank briefly and then prompt for a high reference source. (See Table 6-12.)

4. Apply the requested reference source and press STORE. The display will blank briefly, and the 8840A will then begin taking readings in the selected range so that you may verify the calibration. The CAL annunciator remains on.

5. To continue, select another range. You may restart any of the calibration procedures by pressing the appropriate function button, the A/D button, or the HF AC button.

6-18. VERIFYING CALIBRATION

When you complete certain parts of the calibration procedure, the 8840A automatically begins taking readings so that you can verify the calibration is correct. (It is recommended that you do so.) The CAL annunciator remains lit. The 8840A continues to take readings until you select another calibration procedure or exit the calibration mode.

Specifically, the 8840A begins taking verification readings after:

1. Completing A/D Calibration.

2. Completing Offset and Gain or High-Frequency AC Calibration.

3. Completing the calibration of an individually selected range.

While the 8840A is taking verification readings, certain buttons are active or function differently:

1. If you just completed the Offset and Gain or High-Frequency AC Calibration for an entire function (not just one range), the range buttons can be used to change ranges in order to verify all ranges were calibrated correctly.

Table 6-12. Prompts When Calibrating Individual Ranges

PROCEDURE	FUNCTION	LOW PROMPT	HIGH PROMPT
Offset and Gain Calibration	VDC	Zero	95% of full scale[1]
	kΩ	Zero	50% of full scale
	VAC	5% of full scale[2]	50% of full scale[2]
High-Frequency AC Calibration	(Not applicable)	(No low prompt)	50% of full scale[3]

1. Exception: The 1000V dc range has a high prompt of 1000V dc.
2. Exception: The 700V ac range has a low prompt of 100V ac and a high prompt of 500V ac.
3. Exception: The 700V ac range has a prompt of 200V ac.

2. If you just calibrated an individually selected range, pressing another range button begins the Offset and Gain Calibration procedure for the new range.

3. You can use the RATE button to verify the calibration at other reading rates.

CAUTION

It is still possible to erase the calibration memory while the 8840A is taking verification readings.

6-19. ERASING CALIBRATION MEMORY

The 8840A allows you to erase some or all of the correction constants stored in calibration memory (U220). It is recommended that you erase the entire calibration memory before beginning calibration if the calibration memory is replaced or accidentally altered. The capability of erasing particular parts of the memory is mainly intended as a troubleshooting aid to the technician.

CAUTION

Once the calibration memory is erased, the 8840A must be recalibrated.

To erase all or part of the calibration memory, proceed as follows:

1. Press the front panel ERASE button. The display should show the erase prompt "cl" (for "clear"). If you do not press another button within 1-1/2 seconds, the 8840A returns to its previous state.

2. To complete an erasure, press one of the following buttons within 1-1/2 seconds of pressing the ERASE button:

   a. STORE -- Erases the entire memory.

   b. A D -- Erases the A/D Calibration constants

   c. Any function button -- Erases the Offset and Gain Calibration constants for all ranges of that function.

   d. HF AC -- Erases the High-Frequency AC Calibration constants.

After an erasure is finished (a complete erasure takes about 3 seconds), the 8840A returns to one of the following states:

a. After complete erasure: Begins A/D Calibration.

b. After A/D erasure: Begins A/D Calibration.

c. After Offset and Gain erasure: Begins Offset and Gain Calibration for erased function.

d. After High-Frequency AC erasure: Begins High-Frequency AC Calibration.

6-20. TOLERANCE CHECK

The 8840A automatically checks that the reference input is near the value prompted. This minimizes common errors such as applying a reference source with the wrong sign. If the reference input exceeds the tolerances shown in Table 6-13, the 8840A displays ERROR 41.

If ERROR 41 occurs, the most likely cause is that the reference input is incorrect (e.g., has the wrong polarity). If the input is in fact correct, refer to the Troubleshooting heading in this section.

6-21. AC CALIBRATION AT OTHER FREQUENCIES

For special applications where the 8840A is to be used to measure ac voltages or currents exclusively at a single frequency or narrow range of frequencies, accuracy may be enhanced at that frequency (or range of frequencies) by performing calibration according to the following procedure. Note that this may degrade the accuracy at frequencies significantly removed from the frequency of optimization.

Table 6-13. Tolerance Limits

CALIBRATION	TOLERANCE
1. A/D Calibration	±244 counts from prompt
2. Offset and Gain Calibration	
VDC, mA DC	±488 counts from prompt
Ohms	±3002 counts from prompt
VAC, mA AC	±3002 counts from prompt
3. HF AC Calibration	±9999 counts from prompt

To optimize performance at a frequency less than 1 kHz, perform the offset and gain calibration procedure, above, using the frequency at which measurements will be made rather than 1 kHz. This technique may be used for both the VAC and mA AC functions. At the calibration frequency, the 8840A will yield accuracy closely approaching the specified mid-band performance.

To optimize performance at a frequency greater than 1 kHz, perform calibration as follows:

1. Perform the Offset and Gain Calibration procedure using inputs at 1 kHz.

2. Perform the High-Frequency AC Calibration procedure using inputs at the desired frequency of optimization rather than at 100 kHz. Skip step 5 in that procedure.

3. Again perform the Offset and Gain Calibration procedure, this time using inputs at the desired frequency of optimization rather than at 1 kHz.

6-22. OPTIMIZING USE OF THE 5450A

If the Fluke 5450A Resistance Calibrator is used to calibrate the 2-wire ohms function, the following procedure is recommended to optimize the calibration of the lowest two ranges. (The 5450A has a 25 mΩ "floor" which would otherwise result in 25 digits of error in the 200Ω range of the 8840.) In this procedure, the 8840A is referred to as the unit under test (UUT).

1. Complete Offset and Gain Calibration for the UUT's 4-wire ohms function. The UUT will then be taking verification readings.

2. Connect the UUT to the 5450A as shown in Figure 6-4.

3. Select the "SHORT" from the 5450A, and measure this value at the 5450A OUTPUT terminals using the UUT in 4-wire ohms. If in remote, take the average of four readings. (In remote calibration, the averaged value can be stored in the controller.) Record the value.

4. Select the "100Ω" output from the 5450A, and measure this value as in step 3.

5. Find and record the numerical difference between the values measured in steps 3 and 4. This value will be used as the variable input for calibrating the 200Ω range in 2-wire ohms.

6. Repeat steps 4 and 5 using the "1 kΩ" output from the 5450A; find and record the numerical difference between this and the "SHORT" measured in step 3. This value will be used as the variable input for calibrating the 2 kΩ range in 2-wire ohms.

7. Press the UUT's 2 WIRE kΩ button. This selects the Offset and Gain calibration procedure for the 2-wire ohms function and prompts for zero input. Select the "SHORT" from the 5450A, and calibrate all the zeros by pressing STORE.

8. Select the "100Ω" output from the 5450A and calibrate the high point for the 200Ω range, entering the value computed in step 5 as a variable input.

9. Select the "1 kΩ" output from the 5450A and calibrate the high point for the 2 kΩ range, entering the value computed in step 6 as a variable input.

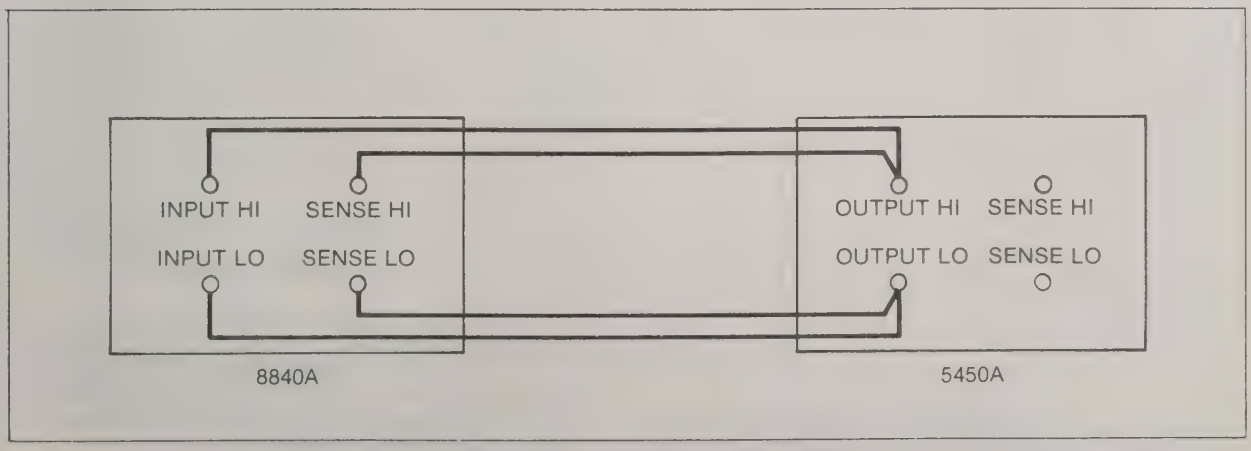


Figure 6-4. Optimizing Use of the 5450A

10. Calibrate the remaining ranges (steps D-G of Table 6-10) using the 5450A outputs.

11. Recalibrate the low point for each 2-wire ohms range using a shorting link (Pomona MDP-S-0 or equivalent) across the UUT's HI and LO INPUT terminals.

12. Exit the calibration mode by pressing the CAL ENABLE switch.

13. Using the same configuration shown in Figure 6-4, verify that the UUT measures the same value (within 1 digit) in 2-wire ohms (using the offset feature to correct for 5450A floor error) as in 4-wire ohms. If the readings differ by more than 1 digit, reenable the calibration mode and repeat steps 2 through 8.

14. Cover the CAL ENABLE switch with a calibration certification sticker.

6-23. Remote Calibration

If the IEEE-488 Interface is installed, the 8840A can be calibrated under remote control. Remote calibration is very similar to local (front-panel controlled) calibration. Table 6-14 shows the remote commands which correspond to the front panel features.

To facilitate remote calibration, there are some differences from local calibration:

1. In remote calibration, you can store a 16-character message in the calibration memory which can be read by the system controller. Possible uses include storing the calibration date, instrument ID, etc.

2. Although some buttons are ignored in local calibration (e.g., the AUTO button), the corresponding remote commands (e.g., R0) load the output buffer with an error message.

3. The calibration memory is erased differently. (This is explained later.)

4. The rear panel SAMPLE COMPLETE signal acts slightly differently. During calibration, the SAMPLE COMPLETE signal is inactive. When the 8840A is taking verification readings, the SAMPLE COMPLETE signal acts the same as in normal operation.

Note that a command may be valid in some parts of the calibration procedure but not in others. The Get Input Prompt (G2) command, for instance, is not valid when the 8840A is taking verification readings. The Rate (Sn) commands, for instance, are valid when the 8840A is taking verification readings, but they are not valid at any other time during calibration. Table 6-15 shows when commands are invalid.

6-24. TIMING CONSIDERATIONS

The C0 command, can take up to 22 seconds. If during this time the controller continues to send the 8840A more commands, the commands may fill up the 8840A's input buffer. If this happens, errors will probably occur.

You can avoid this problem by knowing when these commands are completed. There are three ways to determine this:

1. Monitoring the Cal Step Complete bit in the serial poll status register. This status bit is set false every time the remote processor sends a command to the in guard processor. It is then set true when the in guard processor completes the command and is ready to accept more. So you can send a command and loop on a check of the status, until the command is complete.

2. Setting the SRQ mask to generate an SRQ on Cal Step Complete. The Cal Step Complete bit in the serial poll status response indicates when a cal command in progress. This approach depends on capabilities of the controller being used.

3. Executing a delay in controller software after sending each command. (Not recommended.)

Although not usually necessary, these methods can be used for other commands as well.

6-25. REMOTE ERASURE

The C3 command allows you to erase the entire calibration memory. The erasure is executed by sending the string "C3 C0" (equivalent to pressing ERASE and then STORE). Any command other than C0 after C3 will abort the erasure. To facilitate remote calibration, the C0 command does not timeout as does the front panel ERASE button. The selective erasure that is possible from the front panel is intended as a troubleshooting aid, and is not available over the IEEE-488 Interface.

Note that the erase command can take up to 3 seconds to execute. To prevent timeout problems with the controller, you must determine when the command is completed before continuing. Several methods are presented in Timing Considerations, above.

Table 6-14. Commands Used During Remote Calibration

FRONT PANEL FEATURE	CORRESPONDING COMMAND	COMMENTS
Display	G2	Loads the calibration prompt into the output buffer. Not valid when the 8840A is taking verification readings.
Function Buttons	F1 through F6	In the calibration mode, these select the Offset and Gain Calibration procedure for the corresponding function.
Range	R1 through R6	In the calibration mode, these select the Offset and Gain Calibration procedure for the corresponding range in the presently selected function. (For entering variable inputs, see VAR IN below.)
STORE	C0	Tells the 8840A that the requested calibration input is valid. This command causes the 8840A to take readings, and compute and store calibration constants. NOTE The C0 command can take up to 22 seconds to execute. You must determine when this command is complete before sending more commands. See Timing Considerations in text.
A/D	C1	Selects the A/D Calibration procedure.
HF AC	C2	Selects the High-Frequency AC Calibration procedure.
ERASE	C3	After receiving this command the display shows the erase mode prompt ('cl'). (The prompt is not loaded into the output buffer.) To complete the erasure you must then send C0. Sending any other command after the C3 command causes the 8840A to return to its previous state. There is no timeout as with the front panel ERASE button. CAUTION The command string 'C3 C0' erases the entire calibration memory. A complete calibration must then be performed.
RATE	S0 through S2	Changes the reading rate while the 8840A is taking verification readings. Causes an error at any other time during calibration.
VAR IN	N⟨value⟩P2	Enters ⟨value⟩ as a variable input. (See Entering Variable Inputs, in text.) Causes an error if sent during A/D Calibration or when the 8840A is taking verification reading. You can check that the command was successful by checking the error status or by sending the Get Calibration Input command (G2).
--	P3⟨string⟩	Puts the ⟨string⟩ into calibration memory. The string may contain up to 16 ASCII characters, and can be recalled with the G3 command.

NOTE: Other commands that may be used during calibration are: P1 (Put SRQ mask); the remaining Get commands; and X0 (Clear Error Register).

Table 6-15. Error Numbers Which Are Displayed When Commands Are Not Valid

COMMAND	NORMAL MODE	SELF TEST	CALIBRATION MODE			
			A/D CAL	OFFSET & GAIN CAL	HF AC CAL	VERIFICATION MODE
Bn		60	52	52	52	52
C0	51	60				54
C1	51	60				
C2	51	60				
C3	51	60				
Dn		60	52	52	52	52
Fn		60				
G0						
G1						
G2	51	60				54
G3		60				
G4						
G5						
G6						
G7						
N						
P0		60	52	52	52	52
P1						
P2	51	60	56			54
P3	51	60				
R0		60	52	52	52	52
R1-6		60	52			
R7		60	52	52	52	52
Sn		60	52	52	52	
Tn		60	52	52	52	52
Wn						
X0						
Yn						
Z0		60	52	52	52	52
*		60	52	52	52	52
?		60				
QK		60				

NOTE

When erasing calibration memory, it is good practice to send the commands C3 and C0 in the same command string. Sending C3 by itself could lead to accidentally erasing calibration memory, since the C3 command does not time out as does the ERASE button.

6-26. EXAMPLE CALIBRATION PROGRAM

An example A/D calibration program is shown in Figure 6-5. The program is written in Fluke BASIC for the Fluke 1722A Instrument Controller. It uses the Fluke 5440A Direct Voltage Calibrator to perform and then verify the A/D Calibration procedure. In this program, the 8840A is at bus address 1, and the 5440A is at bus address 7.

6-27. DISASSEMBLY PROCEDURE

WARNING

TO AVOID ELECTRIC SHOCK, REMOVE THE POWER CORD AND TEST LEADS BEFORE DISASSEMBLING THE INSTRUMENT.

```
This program performs the A/D Calibration procedure and then verifies the
A/D Calibration is correct. The program uses the Fluke 1722A Instrument
Controller and the Fluke 5440A Direct Voltage Calibrator. The 8840A is at
bus address 1, and the 5440A is at bus address 7.


10 DIM V(6)
20 DIM W(6)
30 DATA 0.0, 2, 0.03, 2,-0.03, 2, 0.66, 3,-0.66, 3, 1.97, 4,-1.97, 4
40 FOR A=0 TO 6 STEP 1 ! LOOP TO READ IN VERIFICATION VALUES.
50  READ V(A),W(A)
60 NEXT A
70  INIT PORT 0        ! INITIALIZE SYSTEM.

90 REMOTE @1
100 !GOTO 290          ! PROVIDES MEANS TO DO VERIFICATION ONLY.
110 PRINT "PUT 8840 IN CAL MODE, THEN HIT (RETURN)."      ! INSTRUCTION NOTE.
120 INPUT Z$                          ! STOP PROGRAM UNTIL (RETURN) IS HIT.
130 FOR M=1 TO 2                      ! LOOP FOR NO. OF PASSES.
140  PRINT @7, "SOUT 0.0;OPER"        ! SET 5440A OUTPUT TO 0.0
150  WAIT 1000
160  PRINT @1, "C1"                   ! PUT 8840A IN A/D CAL.
170  FOR N=0 TO 11 STEP 1             ! CALIBRATION LOOP.
180   PRINT @1,"G2"
190   INPUT @1,C                      ! GET 8840A CAL PROMPTS.
200   IF C > 1000 GOTO 180            ! CLEARS POSSIBLE ERROR MESSAGE IN BUFFER.
210   PRINT "PASS","STEP","INPUT"     ! LABELS.
220   PRINT M,N,C                     ! DISPLAY PASS,STEP,INPUT VALUE.
230   PRINT @7, "SOUT";C              ! SET OUTPUT OF 5440A.
240   WAIT 7500                       ! SETTLING TIME FOR 5440A.
250   PRINT @1, "CO "                 ! STORE CAL.
260   IF (SPL(1%) AND 8%) <> 8% GOTO 260    ! TEST 8840A FOR CAL STEP COMPLETE.
270  NEXT N
280 NEXT M
290 PRINT "VERIFICATION"
300 WAIT 3000
310 FOR T=0 TO 6 STEP 1               ! VERIFICATION LOOP.
320  PRINT @7,"SOUT";V(T)             ! SET 5440A OUTPUT.
330  WAIT 7500                        ! SETTLING TIME FOR 5440A.
340  INPUT @1,R                       ! GET READING FROM 8840A.
350  R$ = NUM$(R,"S#.#####")          ! THIS AND NEXT 3 LINES FORMATS DISPLAY.
360  IF MID(R$,2,1) = "0" THEN R$ = LEFT(R$,1)+" "+RIGHT(R$,3)
370  IF LEFT(R$,1) = " " THEN R$ = "+"+RIGHT(R$,2)
380  PRINT R$,                        ! PRINTS DISPLAY.
390  IF ABS(R-V(T))<=W(T)*1E-5+1E-6 THEN PRINT "PASS" ELSE PRINT "FAIL"
400 NEXT T
410 END
```

Figure 6-5. Example A/D Calibration Program

CAUTION

To avoid contaminating the printed circuit assemblies (PCAs), handle the PCAs by their edges. Do not handle the areas of the PCAs that are not solder masked unless absolutely necessary. These areas must be cleaned if contaminated.

The following paragraphs present a disassembly procedure for the 8840A. The procedure should be performed in the order presented. Remove the case first, and then remove Option -09, the True RMS AC PCA, Option -05, the IEEE-488 Interface PCA, the Main PCA, and the front panel. For reference, see the final assembly drawing in Section 7.

6-28. Case Removal

1. Remove the grounding screw from the bottom of the case. Remove two rear bezel mounting screws. (See Figure 6-6A.)

2. While holding the front panel, slide the case and rear bezel off the chassis (See Figure 6-6B). (At this point, the rear bezel is not secured to the case.)

6-29. True RMS AC PCA Removal (Option -09 Only)

The True RMS AC PCA should be removed by reversing the last three steps in Figure 809-1 (see Section 8).

1. Release the True RMS AC PCA from the chassis by pulling the four plastic latches upward (Figure 809-1E).

2. Raise the True RMS AC PCA slightly, and disconnect the red lead from the connector (J301) located on the Main PCA (Figure 809-1C).

3. Disconnect the ribbon cable from the Main PCA by releasing the ribbon connector latches (push outward; see Figure 809-1D) and pulling the ribbon cable directly outward from the connectors (Figure 809-1C).

4. Lift the True RMS AC PCA out of the chassis.

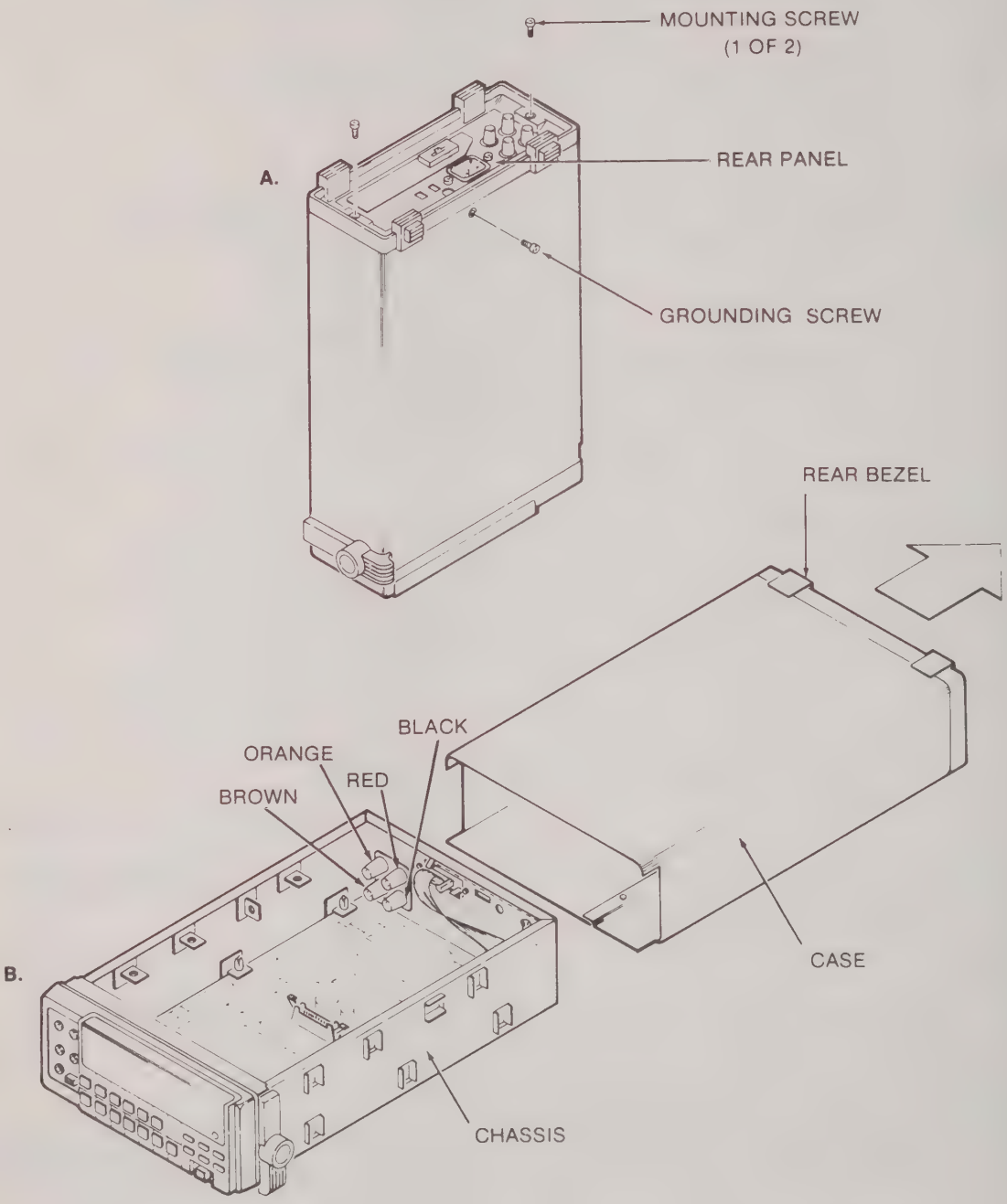


Figure 6-6. 8840A Disassembly

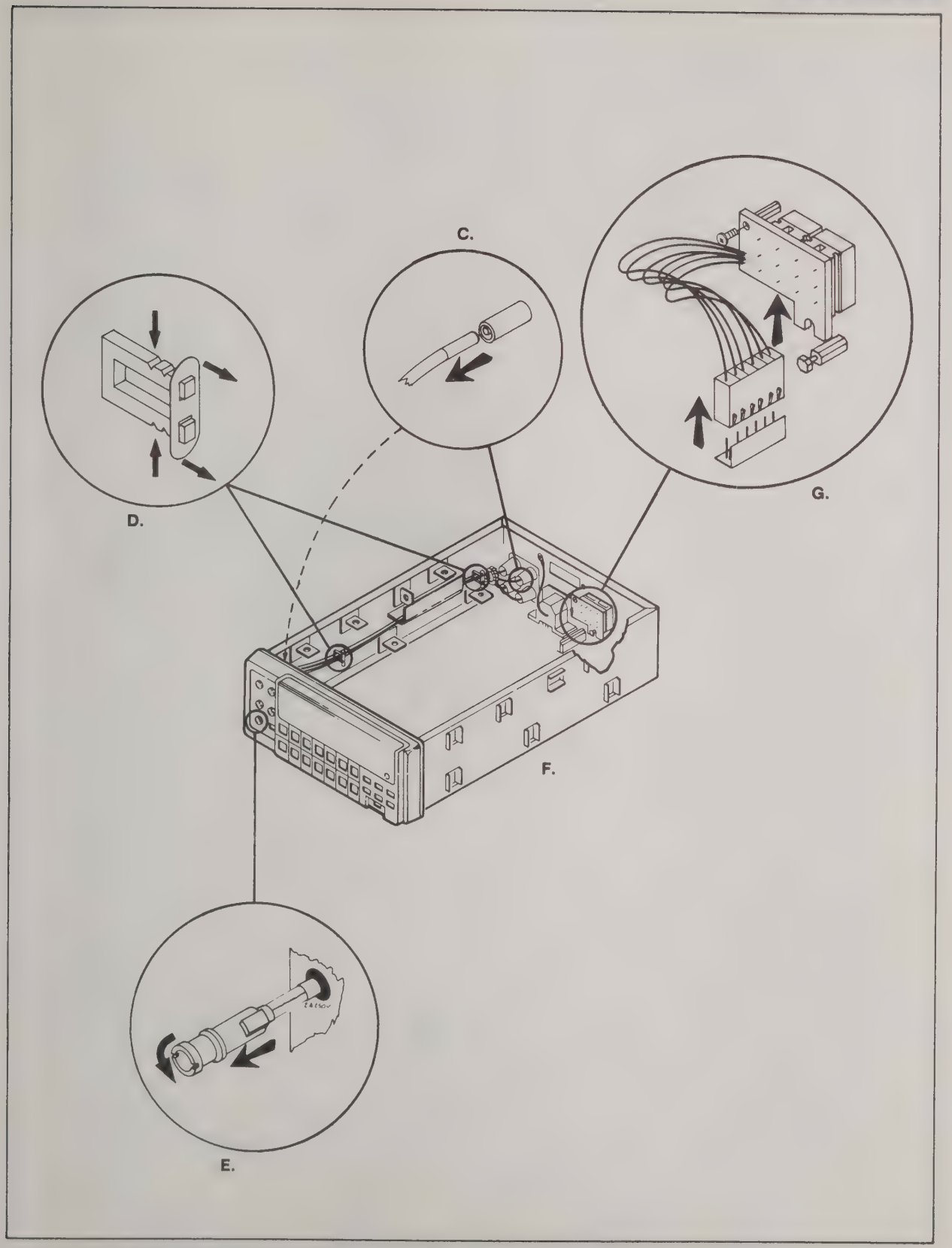


Figure 6-6. 8840A Disassembly (cont)

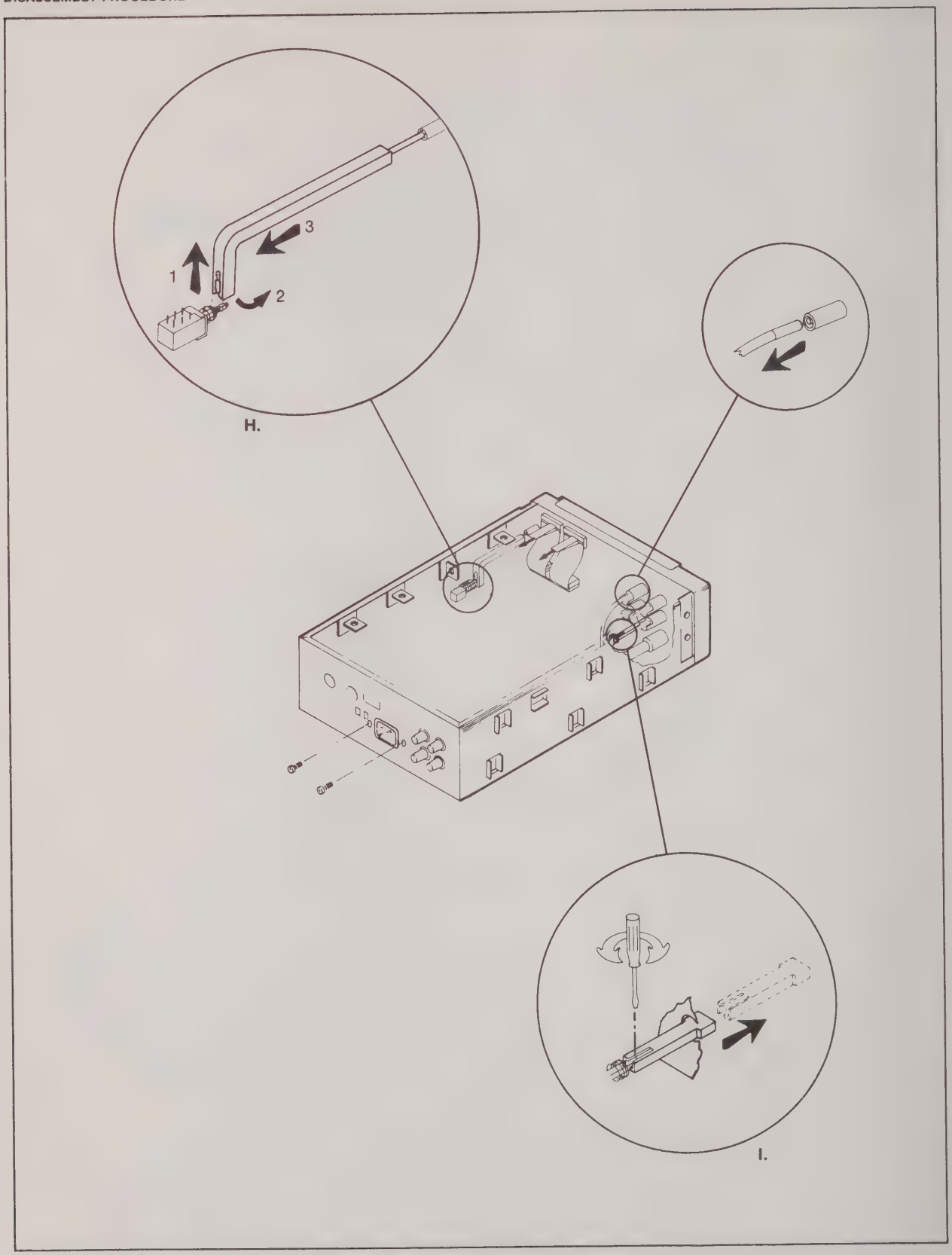


Figure 6-6. 8840A Disassembly (cont)

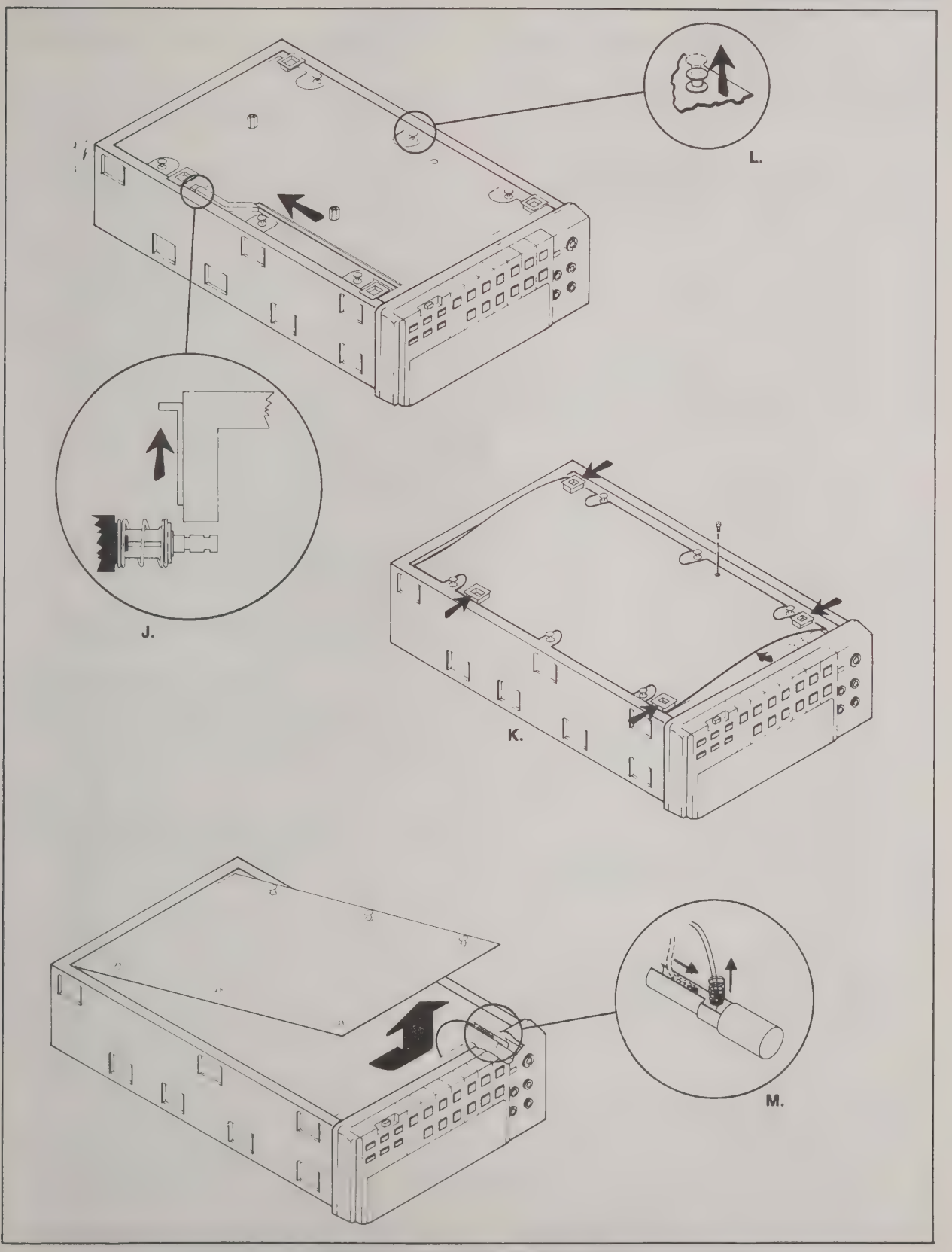


Figure 6-6. 8840A Disassembly (cont)

6-30. IEEE-488 Interface PCA Removal (Option -05 Only)

The IEEE-488 Interface PCA should be removed by reversing the last four steps in Figure 805-1 (see Section 8):

1. Remove the two jack screws and washers from the rear panel IEEE-488 connector (Figure 805-1H).

2. Release the IEEE-488 Interface PCA from the chassis by pulling the two plastic latches upward (Figure 805-1H).

3. Raise the forward edge of the IEEE-488 Interface PCA slightly, pull the PCA towards the front panel (guiding the IEEE-488 jack and BNC connectors out of the rear panel), and lift the PCA out of the chassis (Figure 805-1G).

4. Disconnect the ribbon cable from the IEEE-488 Interface PCA by releasing the connector latches (push outward; see Figure 805-1F) and pulling the ribbon cable out from the connector (Figure 805-1E).

6-31. Main PCA Removal

1. Disconnect the leads from the four front panel input terminals and the four rear panel input terminals by unplugging them. (Refer to Figure 6-6C.)

2. Remove the cable harness from the two cable clamps on the side of the instrument chassis. (Figure 6-6D.) Lift the cable harness clear of the sidewall cable guide.

3. Remove the front panel fuse by pressing in the lip of the 2A input terminal slightly and rotating it ¼-turn counterclockwise (Figure 6-6E).

4. (Disregard this step if the IEEE-488 Interface was installed.) Disconnect the ribbon cable from the rear panel insert by pushing outward on the snap tab on either side of the ribbon cable connector.

5. Disconnect the two ribbon cables from the Display PCA by pulling the two plastic pull tabs directly outward from the Display PCA.

6. Remove the two mounting screws on either side of the rear panel power receptacle.

7. Disconnect the green power supply ground lead from the rear panel mounting stud. (The stud is located near the rear panel power receptacle. See Figure 6-6F.)

8. Remove the Line Voltage Selection Switch (LINE SET) PCA as follows (Figure 6-6G):

   a. Remove the upper screw that holds the LINE SET PCA to the upper rear panel standoff.

   b. Unplug the ribbon cable from the Main PCA and lift out the LINE SET PCA.

9. Remove the push rod for the CAL ENABLE switch as follows (Figure 6-6H):

   a. While supporting the white plunger of the CAL ENABLE switch with a finger, pop the push rod off the switch plunger by pulling the push rod directly upward.

   b. Rotate the push rod 90 degrees toward the center of the instrument.

   c. Pull the push rod toward the rear panel and remove it.

10. Remove the FRONT/REAR switch push rod as follows (Figure 6-6I):

    a. Insert a blade-type screw driver in the slot visible on the top of the FRONT/REAR switch push rod at the junction of the push rod and the switch.

    b. Twist the screwdriver slightly to release the push rod from the switch shaft, then pull the FRONT/REAR switch push rod out through the front panel.

11. Place the chassis on its side.

12. Remove the POWER switch push rod as follows (Figure 6-6J):

    a. Insert a blade-type screwdriver in the slot visible on the top of the POWER switch push rod at the junction of the push rod and the switch.

    b. Twist the screwdriver slightly to release the push rod from the switch shaft, then pull the rear of the POWER switch push rod out through the bottom of the chassis.

    c. Lift the push rod out and toward the rear panel, and remove it.

13. Remove the Main Shield as follows (Figure 6-6K):

    a. Remove the screw that fastens the Main Shield to the Main PCA.

    b. Grasp the Main Shield supports on one side of the instrument and pull the supports toward the center of the chassis, bowing the Main Shield. Remove the main shield.

14. Release the six plastic latches that hold the Main PCA to the chassis by pulling the latches upward (Figure 6-6L).

15. Lift the front end of the Main PCA upward about 3 inches.

16. Free the white lead from the 2A INPUT tower as follows (Figure 6-6M):

    a. Guide the wire, spring and fuse contact toward the front panel.

    b. Thread the spring and fuse contact through the hole in the front end of the tower.

17. Slide the Main PCA forwards until it is free of the chassis.

6-32. Front Panel Disassembly

1. Holding the chassis vertically (with the front panel downward), remove the mounting screws from the four corners of the Display PCA (Figure 6-7A).

2. Holding the chassis vertically (now standing the instrument on the rear panel), pull the front panel off the chassis and set it aside (Figure 6-7B).

3. Remove the the display assembly (Display PCA, spacer matrix, and keypad) from the chassis as follows (see Figure 6-7C):

    a. Release the two plastic tabs on the front of the chassis.

    b. Let the bottom edge of the display assembly swing toward the rear of the instrument.

    c. Pull the Display PCA toward the bottom of the chassis.

4. Separate the spacer matrix from the Display PCA by releasing the two pairs of plastic snap tabs on the back of the Display PCA (Figure 6-7D).

5. Remove the keypad from the spacer matrix.

CAUTION

The vacuum fluorescent display should not be removed from the Display PCA; these are supplied as one part.

6. Remove the display window from the front panel as follows:

    a. Slide the window upward (away from the buttons) about 1/32 inch (Figure 6-8A).

    b. Push the window directly outward from the front panel (Figure 6-8B).

6-33. REASSEMBLY PROCEDURE

To reassemble the instrument, proceed as follows:

1. Assemble the front panel assembly by reversing the front panel disassembly procedure (Figure 6-7). (It is easiest to lay the keypad on the Display PCA before installing the spacer matrix on the Display PCA.)

CAUTION

The four Display PCA mounting screws are self-tapping. To avoid damaging the threads, ensure the screws are threaded properly before tightening. Do not overtighten them.

2. Turn the chassis upside down.

3. Install the Main PCA through the bottom of the chassis as follows:

NOTE

When installing the Main PCA, guide the rear ribbon cable around the shield connected to the rear panel so that the cable is next to the side of the chassis. Make certain that the cable is not pinched between the shield and the Main PCA.

    a. Slide the Main PCA toward the rear panel, and position the power connector and fuse to fit through their respective openings in the rear panel.

    b. Reinstall the white lead in the 2A INPUT tower and reinstall the 2A fuse in the front panel.

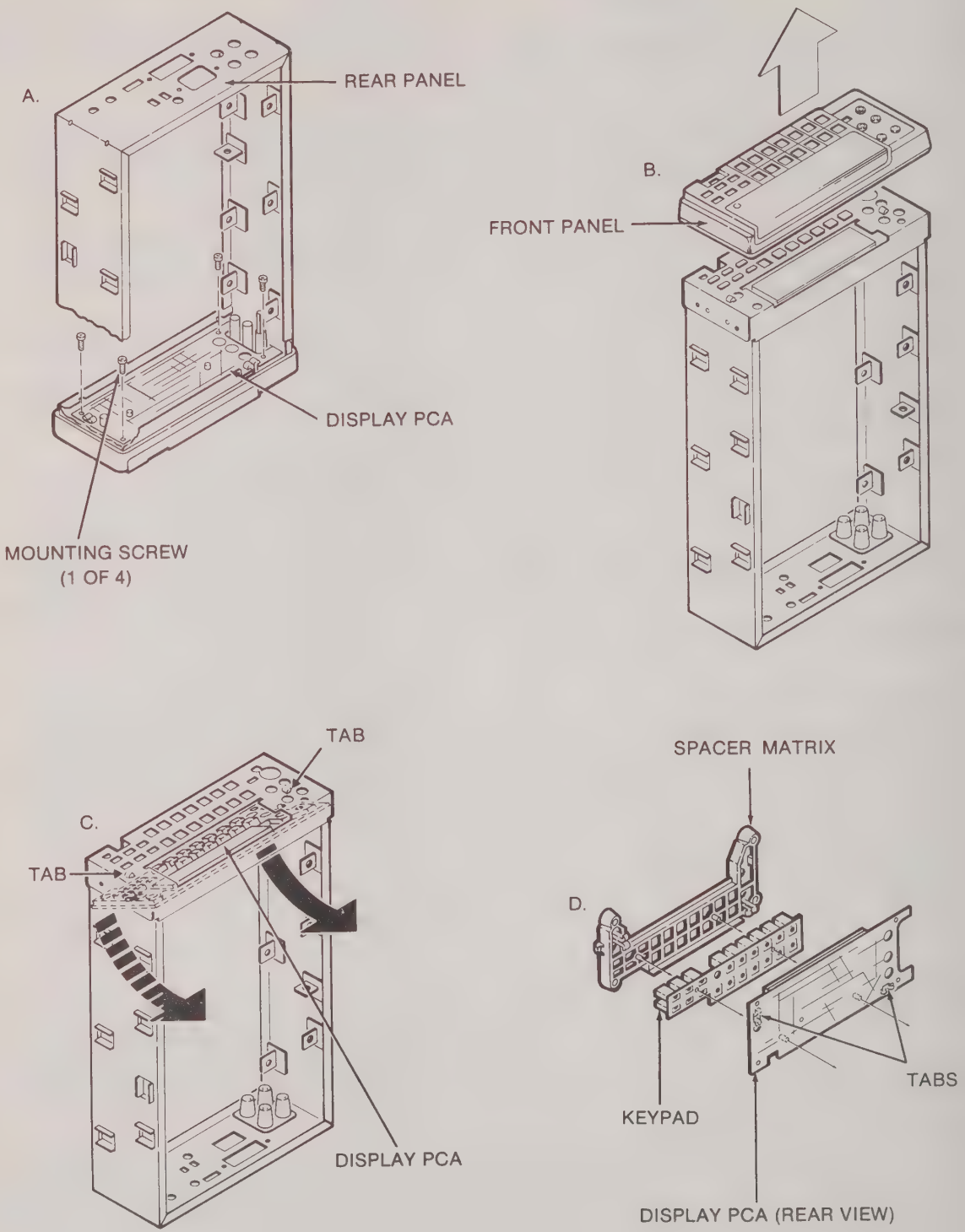


Figure 6-7. Front Panel Disassembly

c. Make sure the six plastic latch heads are extended. Lower the Main PCA into position on the chassis and quide the six plastic latches into the circuit board supports on the chassis. Press the latch heads to lock the board in the chassis. Refer to Figure 6-6L.

4. Install one side of the Main Shield; bow it to install the the other side, and secure it to the Main PCA with the retaining screw.

5. Replace the push rod for the POWER switch as follows:

   a. Insert the button end of the push rod into the rear of the front panel.

   b. While supporting the opposite side of the plunger with your finger, snap the other end of the push rod onto the POWER switch plunger. Refer to Figure 6-6J.

6. Set the chassis right side up.

7. Insert the FRONT/REAR switch push rod through the front panel and snap it into place.

8. Reinstall the CAL ENABLE switch push rod by inserting the cylindrical end of the push rod into the rear of the front panel, then snaping it onto the CAL ENABLE switch plunger.

CAUTION

Make certain that the CAL ENABLE switch shaft is in the out (disabled) position after the CAL ENABLE push rod is installed. If the 8840A is switched on with the CAL ENABLE switch in the enabled position, the 8840A may require recalibration.

9. Position the slot in the lower edge of the Line Voltage Selection Switch PCA in the slot on the lower rear panel standoff. Secure the top of the Line Voltage Selection Switch PCA to the upper standoff using the single mounting screw, and plug the ribbon cable into the Main PCA.

10. Connect the power supply ground lead to the rear panel mounting stud. (The stud is located near the rear panel power receptacle as shown in Figure 6-6F.)

WARNING

TO AVOID ELECTRIC SHOCK, ENSURE THAT THE POWER SUPPLY GROUND LEAD IS FIRMLY ATTACHED TO THE REAR PANEL MOUNTING STUD.

11. Attach the two mounting screws on either side of the rear panel power receptacle.

12. Connect the two ribbon cables to the Display PCA to the connectors. Push the cables straight in to avoid damage.

13. Reinstall the harness in the sidewall cable guide, and secure the harness to the chassis with the cable clamps.

14. Connect the leads to the four front panel input terminals according to the color codes marked on the rear side of the Display PCA.

15. Connect the leads to the four rear panel input terminals following the color codes as shown in Figure 6-6B.

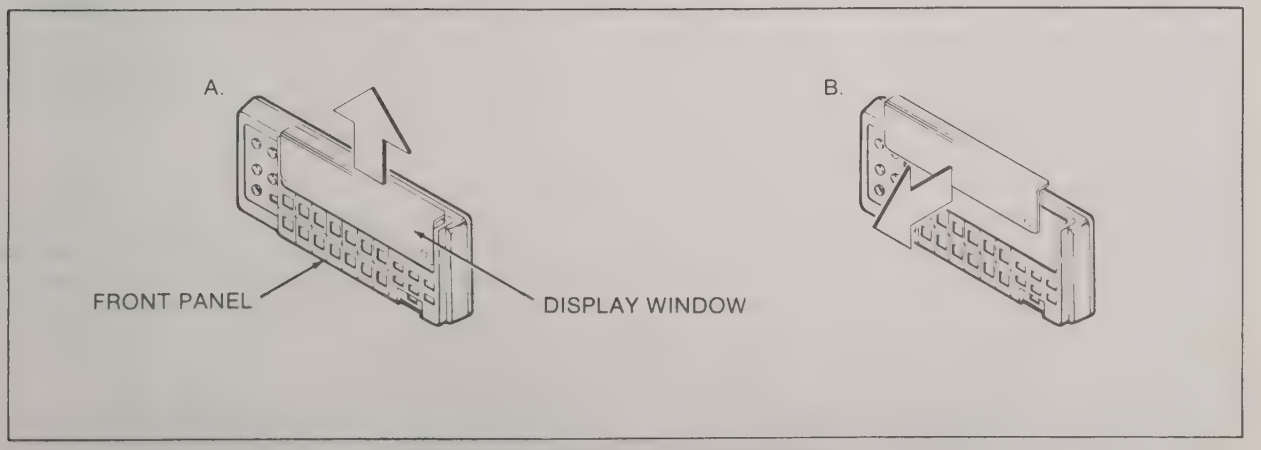


Figure 6-8. Removing The Display Window

16. (Option -05 only) Install the IEEE-488 Interface PCA according to the instructions in Section 8.

17. (Option -09 only) Install the True RMS AC PCA according to the instructions in Section 8.

18. Slide the case and rear bezel onto the chassis.

19. Install the two rear panel mounting screws.

20. Install the case grounding screw in the bottom of the case.

WARNING

TO AVOID ELECTRIC SHOCK, ENSURE THE GROUNDING SCREW IS FIRMLY ATTACHED TO THE CASE BOTTOM.

6-34. INTERNAL FUSE REPLACEMENT

CAUTION

For fire protection, use exact fuse replacements only.

The 8840A has an internal 3A 600V slow-blow fuse (F301) in series with the 2A input terminal. To replace this fuse, remove the case according to the disassembly instructions. The fuse is held in fuse clips on the Main PCA.

6-35. EXTERNAL TRIGGER POLARITY SELECTION (Option -05 Only)

The EXT TRIG input is factory-configured with negative polarity (trigger on falling-edge). This polarity is set by jumper E902 on the IEEE-488 Interface PCA. To select positive polarity (trigger on rising-edge), remove jumper E902 and add jumper E903.

6-36. TROUBLESHOOTING

The 8840A is designed to be easily maintained and repaired. Both the analog and digital circuits have built-in diagnostic self-tests and troubleshooting modes to facilitate troubleshooting and repair. The instrument's circuits allow troubleshooting and repair with basic electronic troubleshooting equipment such as a multimeter and oscilloscope. The troubleshooting mode in the digital controller circuitry generates special test signals to allow troubleshooting and repair without a special test signal generator or complex logic analyzer. Using the information in this section, a technician should be able to troubleshoot and repair the 8840A very efficiently. There is also a troubleshooting package available which utilizes the Fluke 9010A System Troubleshooter. The 8840A-9000 Troubleshooting Kit is described in detail in section 8.

6-37. Initial Troubleshooting Procedure

WARNING

TO AVOID INJURY OR EQUIPMENT DAMAGE, USE EXACT REPLACEMENT PARTS FOR ALL PROTECTION COMPONENTS.

When a problem occurs in the 8840A, first verify the problem is actually in the instrument. If the problem occurs when the instrument is in a system, check to see if the same problem exists when under local control. Watch the display as the instrument is turned on to see if any of the digital self-test error codes appear indicating a digital failure. If the malfunction does not involve the True RMS AC or IEEE-488 options, remove the option(s) from the instrument before proceeding.

If the display lights up, perform the self-test by pressing the SRQ button for 3 seconds. (Remember, the input terminals must be disconnected from the test leads during the self-tests. Otherwise, the 8840A may indicate errors are present.) The test numbers will appear consecutively. "ERROR" will appear on the display if a test should fail. The 8840A can be held in each of the test configurations by momentarily pressing the SRQ button. (Press any button to continue the tests.) With the description of the self-tests given below, it may be possible to isolate the failure. For reference, the states of various switches and logic lines are shown in Table 6-16 for each function, range, and reading rate.

If only one or a few failures appear in the self-tests, the problem is usually in the DC Scaling circuit. By carefully analyzing which failure(s) occurred, the fault can be located to within a few components. (Table 6-17 shows which components are exercised by each of the analog tests.) The heading DC Scaling Troubleshooting provides detailed instructions on locating and repairing DC Scaling circuit problems. However, before troubleshooting the DC Scaling circuit, all of the power supply levels should be measured to verify they are within the limits specified in Table 6-23 under Power Supply Troubleshooting, later in this section.

Some failures will cause many self-tests to fail. If this occurs, the fault is usually in the Track/Hold circuit, the A/D Converter, the Digital Controller circuit, or the Power Supply. Again, measure all of the power supply levels according to the limits specified in Table 6-23. The next step is to isolate the problem to a specific section.

If the self-tests display a large number of errors or if readings are noisy and/or in error, the problem is usually in the A/D Converter or Track/Hold circuit. (A large

Table 6-16. Overall State Table

DEFINITIONS

^	Logical AND
+	Logical OR
-	Logical NOT (e.g., $\bar{r}$)
s	Slow reading rate
m	Medium reading rate
f	Fast reading rate
r	Range (r1 = lowest range)
GB	(VDC^(r3+r5))+(ohms^(r5+r6))
GC	(VDC^(r1+r2+r4))+(ohms^(r1+r2+r3+r4))

The variables HD1, HD2, PC, TR1, and TR2 are dynamic signals generated by the A/D IC (U101). (HD2 = TP2.) These variables are true only when the corresponding dynamic signals are true. For example, the switches in line 8 are on only when when HD1 is true.

A 0 stands for the switch or relay being open, and a 1 stands for it being closed. If a reference designator has a '*' after it, the switch or relay is closed when the control voltage is low (0V). Otherwise, it is closed when the control voltage is high (5V).

NORMAL OPERATING MODE

			VDC					VAC					2-Wire Ohms						4-Wire Ohms						IDC	IAC
		DC Scaling	r1	r2	r3	r4	r5	r1	r2	r3	r4	r5	r1	r2	r3	r4	r5	r6	r1	r2	r3	r4	r5	r6	r5	r5
1	K301*	(VDC^(r1+r2+r3))+ohms	1	1	1	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	0	0
2	Q303	4Wohms	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	0	0
3	Q304	(VDC^s)+(ohms^s^(r1+r2+r3))	s	s	s	s	s	0	0	0	0	0	s	s	s	0	0	0	s	s	s	0	0	0	0	0
4	Q310	$\overline{4Wohms}$	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0	0	0	0	0	1	1
5	Q311	GC	1	1	0	1	0	0	0	0	0	0	1	1	1	1	0	0	1	1	1	1	0	0	0	1
6	U301A-1	PC^GC	1	1	0	1	0	0	0	0	0	0	1	1	1	1	0	0	1	1	1	1	0	0	0	0
7	U301B-5	TR1^GC	1	1	0	1	0	0	0	0	0	0	1	1	1	1	0	0	1	1	1	1	0	0	0	0
8	U301C-7	HD1^($\overline{4Wohms^(r1+r2+r3+r4)}$)	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0	0	0	1	1	1	1
9	U301D-9	HD1^4Wohms	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	0	0
10	U302A-1	GB^TR1	0	0	1	0	1	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	1	1	0	0
11	U302B-5	(m^r1)+(ohms^r4^$\bar{f}$)	m	0	0	0	0	m	0	0	0	0	m	0	0	$\bar{f}$	0	0	m	0	0	$\bar{f}$	0	0	0	0
12	U302C-7	HDI^(VAC+IAC)	0	0	0	0	0	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1
13	U302D-9	HDI^IDC	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
14	U303A-1	TR2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
15	U303B-5	TR2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
16	U303C-7	HD2^x10	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0	1	0
17	U303D-9	HD2^x1	0	1	1	1	1	1	1	1	1	1	0	1	1	1	1	1	0	1	1	1	1	1	0	1
		Ohms Section																								
18	K401*	ohms	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	0	0
19	Q408	GC	1	1	0	1	0	1	1	1	1	1	1	1	1	1	0	0	1	1	1	1	0	0	1	1
20	U402A-1	$\overline{.2k+2k+20k+200k}$	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	1	1	0	0
21	U402B-5	.2k+2k+20k+200k+$\overline{ohms}$	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0	1	1	1	1	0	0	1	1
22	U403A-1	20M	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1	0	0
23	U402D-9	$\overline{20M+ohms}$	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	1	1	1	1	1	0	1	1
24	U402C-7	200k+2000k	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	1	1	0	0	0
25	U403B-5	20k+$\overline{ohms}$	1	1	1	1	1	1	1	1	1	1	0	0	1	0	0	0	0	0	1	0	0	0	1	1
26	U403C-7	$\overline{20M+ohms}$	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	1	1	1	1	1	0	1	1
27	U403D-9	.2k+2k	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	1	1	0	0	0	0	0	0
		AC Option																								
28	K801*	VAC+IAC	0	0	0	0	0	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1
29	K802*	(VAC^(r4+r5))+IAC	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1
30	U804A-1*	(VAC^(r3+r5))+$\overline{AC}$	1	1	1	1	1	0	0	1	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0
31	U804B-8*	(VAC^r1)+IAC	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
32	U804C-9*	(VAC^r1)+IDC	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
33	U804D-16*	VAC^(r2+r4))	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Table 6-16. Overall State Table (cont)

		DIAGNOSTIC SELF-TEST CONDITIONS																			
		TEST NUMBER																			
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
	DC Scaling																					
1	K301* (VDC^(r1+r2+r3))+ohms	0	0	0	0	0	0	0	1	1	1	1	1	1	1	0	0	0	0	0	0	0
2	Q303 4Wohms	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3	Q304 (VDC^s)+(ohms^s^(r1+r2+r3))	0	0	0	0	1	1	1	0	0	1	0	0	0	0	1	1	1	1	1	0	0
4	Q310 $\overline{\text{4Wohms}}$	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
5	Q311 GC	0	0	0	0	1	0	0	0	0	1	1	1	1	1	0	1	1	1	1	1	1
6	U301A-1 PC^GC	0	0	0	0	1	0	0	0	0	1	1	1	1	1	0	1	1	1	1	1	1
7	U301B-5 TR1^GC	0	0	0	0	1	0	0	0	0	1	1	1	1	1	0	1	1	1	1	1	1
8	U301C-7 HD1^($\overline{\text{4Wohms}}$^(r1+r2+r3+r4))	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
9	U301D-9 HD1^4Wohms	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10	U302A-1 GB^TR1	0	0	0	0	0	1	1	1	1	0	0	0	0	0	1	0	0	0	0	0	0
11	U302B-5 (m^r1)+(ohms^r4^F)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12	U302C-7 $\overline{\text{HDI}}$^(VAC+IAC)	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
13	U302D-9 $\overline{\text{HDI}}$^IDC	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
14	U303A-1 TR2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
15	U303B-5 TR2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
16	U303C-7 HD2^x10	0	0	0	1	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0
17	U303D-9 HD2^x1	1	1	1	0	1	1	1	1	1	1	0	1	1	1	0	1	1	1	1	1	1
	Ohms Section																					
18	K401* ohms	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	0	1	0
19	Q408 GC	0	0	0	0	1	0	0	0	0	1	1	1	1	1	0	1	1	1	1	1	1
20	U402A-1 $\overline{\text{.2k+2k+20k+200k}}$	0	0	0	0	0	1	1	1	1	1	0	0	0	0	1	0	0	0	0	0	0
21	U402B-5 .2k+2k+20k+200k+$\overline{\text{ohms}}$	1	1	1	1	1	0	0	0	0	0	1	1	1	1	0	1	1	1	1	1	1
22	U403A-1 20M	0	0	0	0	0	1	1	1	0	0	0	0	0	0	1	0	0	0	0	0	0
23	U402D-9 $\overline{\text{20M+ohms}}$	1	1	1	1	1	0	0	0	1	1	1	1	1	1	0	1	1	1	1	1	1
24	U402C-7 200k+2000k	0	0	0	0	0	0	0	0	1	1	0	0	0	1	0	1	0	0	0	0	0
25	U403B-5 20k+$\overline{\text{ohms}}$	1	1	1	1	1	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0
26	U403C-7 $\overline{\text{20M+ohms}}$	1	1	1	1	1	0	0	0	1	1	1	1	1	1	0	1	1	1	1	1	1
27	U403D-9 .2k+2k	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	1	1	1	1
	AC Option																					
28	K801* VAC+IAC	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
29	K802* (VAC^(r4+r5))+IAC	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
30	U804A-1* (VAC^(r3+r5))+$\overline{\text{AC}}$	0	1	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
31	U804B-8* (VAC^r1)+IAC	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
32	U804C-9* (VAC^r1)+IDC	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
33	U804D-16* VAC^(r2+r4))	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

number of errors can also be caused by a problem in the Ohms Current Source.) To isolate the problem, connect a jumper between TP103 and Reference Low (TP306, or the L-shaped shield around U202). The display should typically read less than approximately 35 counts (i.e., ±.000XX where XX is less than 35) on the 2V dc range. If a good reading can be obtained (less than approximately 35 counts), the A/D Converter and Precision Voltage Reference circuits are most likely good. A more conclusive test can be made by connecting a low-impedance dc source between Reference Low and TP103 with an output voltage between -2.0V and +2.0V. The reading on the display will be of opposite polarity to the voltage applied to TP103. (Disconnecting one end of R318 will usually make it possible to display readings within 0.1% to 0.5% of the actual input.) After it has been determined that the A/D Converter or the Track/Hold circuit is not functioning properly, proceed to the corresponding heading for detailed troubleshooting instructions and guidelines.

A failure in the instrument may cause the 8840A to display random patterns or nothing at all. Usually, analog circuit failures do not cause the display to go blank or display random patterns. The best place to start troubleshooting a "dead" instrument or an instrument with a non-functional display is to check the power supply with a voltmeter for proper levels and to use an oscilloscope to check the supplies for oscillations. If all of the supplies are working correctly, check the clock for the In-Guard μC at U202-2. The signal should be an 8 MHz sine wave approximately 3.5V peak-to-peak. Then check the 1 MHz output of the A/D IC (U101) at U212-3. (If not present, check at the A/D IC at U101-14.) The signal should be a 1 MHz square wave approximately 5V peak-to-peak. The 8 MHz sine wave is generated by the clock circuit of the In-Guard μC, and the 1 MHz signal is the 8 MHz signal divided by a counter in the A/D IC. If the clock signals are correct, proceed to the heading Digital Controller Troubleshooting, below, for detailed troubleshooting instructions.

Table 6-17. Circuitry Tested by the Analog Self-Tests

CIRCUITRY TESTED	TEST NUMBER																				
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
DC:																					
K301					•	•	•	•							•	•	•	•		•	
Q310					•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
Q311					•					•	•	•	•	•		•	•	•	•	•	•
Q304, U304																			•	•	•
R319, R315			•	•																	
U306						•	•	•	•						•						
Z301							•	•	•						•						
Z302							•								•	•	•	•	•	•	•
Z304								•	•	•	•	•	•	•							
T/H:																					
Amplifier				•	•	•	•	•	•						•	•	•	•	•	•	•
U301					•											•	•	•	•	•	•
U302	•	•	•	•		•	•	•	•						•						
U303				•	•	•	•	•	•						•	•	•	•	•	•	•
Z303															•						
OHMS:																					
Protection							•	•	•	•	•	•	•	•	•	•	•	•			
U401, U404							•	•	•	•	•	•	•	•	•	•	•	•			
U402							•	•	•	•	•	•	•	•	•	•	•	•			
U403							•	•	•	•	•	•	•	•	•	•	•	•			
Z401							•								•						
AC:																					
U802	•	•	•																		
U803	•	•	•																		
U804	•	•	•																		
U809	•	•	•																		
A/D	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•

If a problem occurs in the keyboard/display area, the instrument may appear to be totally inoperative even when the measurement circuitry is still functional. The heading Digital Controller Troubleshooting provides detailed instructions on locating problems in the display/keyboard system.

Finally, as in most processor-based systems, there are communication links between the various parts of the system. Specifically, in the 8840A, there is a bus interface between analog and digital control circuits and a guard-crossing interface between logic circuits which may be separated by large potentials. Failures in these links can generate problems that may be difficult to locate and repair. However, such failures will in turn cause failures in some analog and or digital section. Thus, indirectly, troubleshooting the affected section will lead to correction of problems in the internal bus or guard-crossing circuit.

6-38. Diagnostic Self-Tests

To run the diagnostic self-tests, disconnect the test leads and press the SRQ button for 3 seconds. If the test leads are left attached to the input terminals the 8840A may indicate errors are present (most likely, errors 5, 7, 8, 9, and 10). Also, if the FRONT/REAR switch is in the REAR position, the 8840A skips tests 3 and 4, and if Option -09 is not installed, the 8840A skips tests 1, 2, and 3. For all tests, there is a 0.5 second delay period before any readings are taken. The tests are all contingent on the A/D Converter being properly calibrated, but do not depend on the Offset and Gain Calibration constants.

Failing the tests indicates that key portions of the 8840A are not performing properly. Passing the tests gives approximately a 90% probability that all VDC ranges and range r6 of 2-wire ohms can be calibrated. Passing the tests also gives a reasonable probability that it will give accurate measurements in VDC and range r6 of 2-wire ohms. However, passing the tests does not guarantee that the instrument can be calibrated in VAC, mA DC, mA AC, 4-wire ohms, or ranges r1 to r5 of 2-wire ohms.

NOTE

If the A/D Converter or Precision Voltage Reference is not working, all analog tests would show an error. If the A/D Converter is not calibrated, tests 7, 15, 19 could show an error.

If the analog self-tests indicate an error, it may be possible to isolate the problem as follows:

1. While the error code is being displayed, press the SRQ button. This latches the 8840A into the particular test configuration.
2. Referring to Table 6-18, check that the test point voltages are as shown using another DMM.

6-39. Self-Test Descriptions

- TEST 1: 200 VAC, Zero

Configures the 8840A in the 200V ac range (except that K801 is opened) and measures the open-circuit floor reading. In this range, the first and second stage buffers effectively divide any noise at the input terminals by 100. This test should be fairly immune from noise because the input terminals are always open-circuited except for capacitive feedthrough across K801.

- TEST 2: 700 VAC, Zero

Configures the 8840A in the 700V ac range and measures the open-circuit floor reading. In this range, the open-circuit reading is divided by 1000. Again, K801 is opened to reduce sensitivity to external noise.

- TEST 3: mA AC, Zero

Configures the 8840A exactly as in the mA AC function and takes a reading of the voltage across the 0.1Ω current shunt at the slow reading rate.

- TEST 4: mA DC, Zero

Configures the 8840A in the mA DC function and the slow reading rate, and measures the reading across the 0.1Ω current shunt. This test should be fairly immune to outside noise because the total driving impedance is typically less than 1 kΩ. The reading is not a perfect zero because of the offsets generated by charge injection of U302 and the T/H Amplifier (X10 configuration).

- TEST 5: 200 VDC, Zero

Configures the 8840A in the 200V dc range and slow reading rate. Input noise is divided by 100. Assuming no input of any kind, the T/H Amplifier is essentially shorted to ground by 100 kΩ and filtered by the 3-pole analog filter. Any non-zero reading under quiet input conditions is due to the offset of the T/H Amplifier (X1 configuration).

- TEST 6: 1000 VDC, Zero

Configures the 8840A exactly as in the 1000V dc range and slow reading rate, with input noise being divided by 1000. The reading is very close to zero because of the inherent 2 kΩ driving impedance to the T/H Amplifier (X1 configuration).

- TEST 7: 1000 VDC + 20 MΩ

Couples the 1000V dc range and 20 MΩ current source together. The result is nominally 500 nA through the 10 MΩ input divider. Since the 1000V dc range senses this voltage at the divide-by-1000 point of the scaling circuit, the reading should be 5 mV, or 500 counts at the A/D Converter. This test could indicate an error if input capacitance is greater than 1000 pF.

- TEST 8: 20 VDC + 20 MΩ

Puts the DC Scaling circuit into the 20V dc range and the Ohms Current Source into the 20 MΩ range. The infinite input impedance of the 20V dc range causes the 20 MΩ current source to be clamped at its maximum open circuit voltage, typically 12V. The 20V dc range scales this voltage and presents the A/D Converter with 1.15V, or 115,000 counts. This is a good test to ensure that the maximum open-circuit voltage of the Ohms Current Source is less than 13V. This test is susceptible to capacitance greater than 0.01 uF at the input terminals.

- TEST 9: 20 VDC + 2000 kΩ

Puts the DC Scaling circuit in the 20V dc range and the Ohms Current Source in the 2000 kΩ range. The infinite input impedance of the 20V dc range causes the 2000 kΩ current source to be clamped at typically 11.5V. The reading at the A/D Converter should be 1.15V. Again tests that the maximum open-circuit voltage of the Ohms Current Source is less than 13V. Capacitances greater than 0.1 uF at the input terminals can cause an error.

- TEST 10: 2 VDC + 2000 kΩ

Puts the DC Scaling circuit in the 2V dc range and the Ohms Current Source in the 2000 kΩ range, except that its maximum open-circuit voltage is limited to less than 6.5V in this configuration. This test, as well as tests 11-13, checks clamps Q312 and Q313 and the analog filter. The reading at the A/D Converter should be an overload. Capacitances greater than 0.5 uF at the input terminals can cause an error.

- TEST 11: 200Ω, Overrange
- TEST 12: 2 kΩ, Overrange
- TEST 13: 20 kΩ, Overrange
- TEST 14: 200 kΩ, Overrange

These tests put the 8840A in the respective range of the

Table 6-18. Self-Test Voltages

TEST NUMBER	TEST POINT	VOLTAGE
1	TP803	±5 mV dc
2	TP803	±5 mV dc
3	TP803	±5 mV dc
4	TP103	T/H output waveform for zero input (Figure 6-14)
5	TP302	±5 mV dc
6	TP302	±5 mV dc
7	TP302	50 mV dc typical
8	TP302	+11.5V dc typical
9	TP302	+11.5V dc typical
10	TP302	+4.5V dc with possibly 1V ac (p-p) at 10 Hz
11	"	"
12	"	"
13	"	"
14	"	"
15	TP302	+50mV dc typical
16	TP302	+49mV dc typical
17	TP302	+53mV dc typical
18	TP302	+59mV dc typical
19	TP302	<±5 mV dc
20	TP302	+59 mV dc typical
21	TP302	<±5 mV dc

Note: To measure these correctly, each test must be stopped using the SRQ button.

2-wire ohms function. They check that each range of the Ohms Current Source has enough compliance voltage to overload the dc front end.

- TEST 15: 1000 VDC + X10 T/H + 20 MΩ

Puts the Ohms Current Source in the 500 nA range. The resulting current through Z302 (the 10 MΩ input divider) causes a nominal divider output voltage of 50 mV. The T/H Amplifier is in X10; thus the A/D Converter sees 50 mV, or 5000 counts. This test can be susceptible to input capacitances above 1000 pF.

- TEST 16: 200 VDC + 200 kΩ
- TEST 17: 200 VDC + 20 kΩ
- TEST 18: 200 VDC + 2 kΩ

These three tests put the DC Scaling circuit in the 200V dc range and the Ohms Current Source in the respective current range. The 10M ohm input divider (Z302) senses the maximum open-circuit voltage of each range of the current source, and the T/H Amplifier (X1) presents the compliance voltage divided by 100 to the A/D Converter. Nominal readings should be 49 mV for Test 16, 53 mV for Test 17, and 59 mV for Test 18. All three tests have a pass limit of 65 mV, insuring that no more than 6.5 volts appears at the input terminals.

- TEST 19: 200 VDC, Filter On

Test 18 (above) ties the 1 mA range of the Ohms Current Source into the 200V dc range, with the three-pole analog filter on, such that the A/D reads 59 mV nominal. Test 19 decouples the DC Scaling circuit from the Ohms Current Source; the In-Guard μC waits 28 ms and determines if the voltage at Z302-3 (the divide-by-100 point of the 10 MΩ input divider) has not discharged to zero volts, due to the long time constant of the filter.

- TEST 20: 200 VDC + 2 kΩ, Filter Off
- TEST 21: 200 VDC, Filter Off

Test 20 ties the 1 mA range of the Ohms Current Source into the 200V dc range, with the 3-pole analog filter off, such that the A/D Converter reads 59 mV nominal. Test 21 then decouples the DC Scaling circuit from the ohms current source; the In-Guard μC waits 28 ms and determines if the voltage at Z302-3 is at zero volts.

- TEST 25: In-Guard μC Internal RAM (U202)

A GALPAT test is performed on the internal RAM of the In-Guard μC. If there are any errors, ERROR 25 is displayed. This test is performed only upon powerup.

- TEST 26: Display RAM (U212)

A pattern is written to the Display RAM and read back for comparison. If there are any differences ERROR 26 is displayed.

- TEST 27: In-Guard μC Program Memory (U202)

A two-byte check sum is calculated over the entire 4K Internal Program Memory and compared with the checksum bytes at the end of that memory. A special add and shift algorithm minimizes the possibility of double errors cancelling. If something is wrong with the Internal Program Memory, ERROR 27 is displayed.

- TEST 28: External Program Memory (U222)

A two-byte check sum is calculated over the entire 4K External Program Memory and compared with the checksum bytes at the end of that memory. A special add and shift algorithm minimizes the possibility of double errors cancelling. If something is wrong with the External Program Memory, ERROR 28 is displayed.

- TEST 29: Calibration Memory (U220)

Numerous single-byte checksums are placed in the Calibration Memory, one at the end of each group of calibration constants. They are calculated in such a way that the single-byte sum of all bytes in the Calibration Memory add to zero (all carries discarded) and the single-byte sums of each group also add to zero. A new checksum is calculated and written to Calibration Memory each time a full or partial calibration is performed. If the Calibration Memory is not properly configured or not working correctly, ERROR 29 is displayed. The accuracy of the 8840A is suspect.

6-40. Digital Controller Troubleshooting

The basic strategy in troubleshooting the Digital Controller circuit is to check first whether the In-Guard Microcomputer (μC) system is functional, starting with the In-Guard μC itself (U202). Most of this circuitry is tested using the specially provided In-Guard Troubleshooting Mode.

If the In-Guard μC system proves to be functional, then basic instrument control is assured and troubleshooting efforts can proceed in one of two directions. If the display and keyboard appear to be malfunctioning, then they should be checked next. (See Display System, below.) If the display and keyboard are functioning correctly, you can omit Display System troubleshooting and proceed to verify that signals are arriving correctly at the inputs of

the analog control devices. (See Analog Control Signals, below.) If these are also correct, the digital controller is functioning correctly, and you can proceed to the appropriate analog troubleshooting procedure.

NOTE

For the convenience of the following tests, Options -05 and -09 should be removed if present. They should only be removed in the power-off condition.

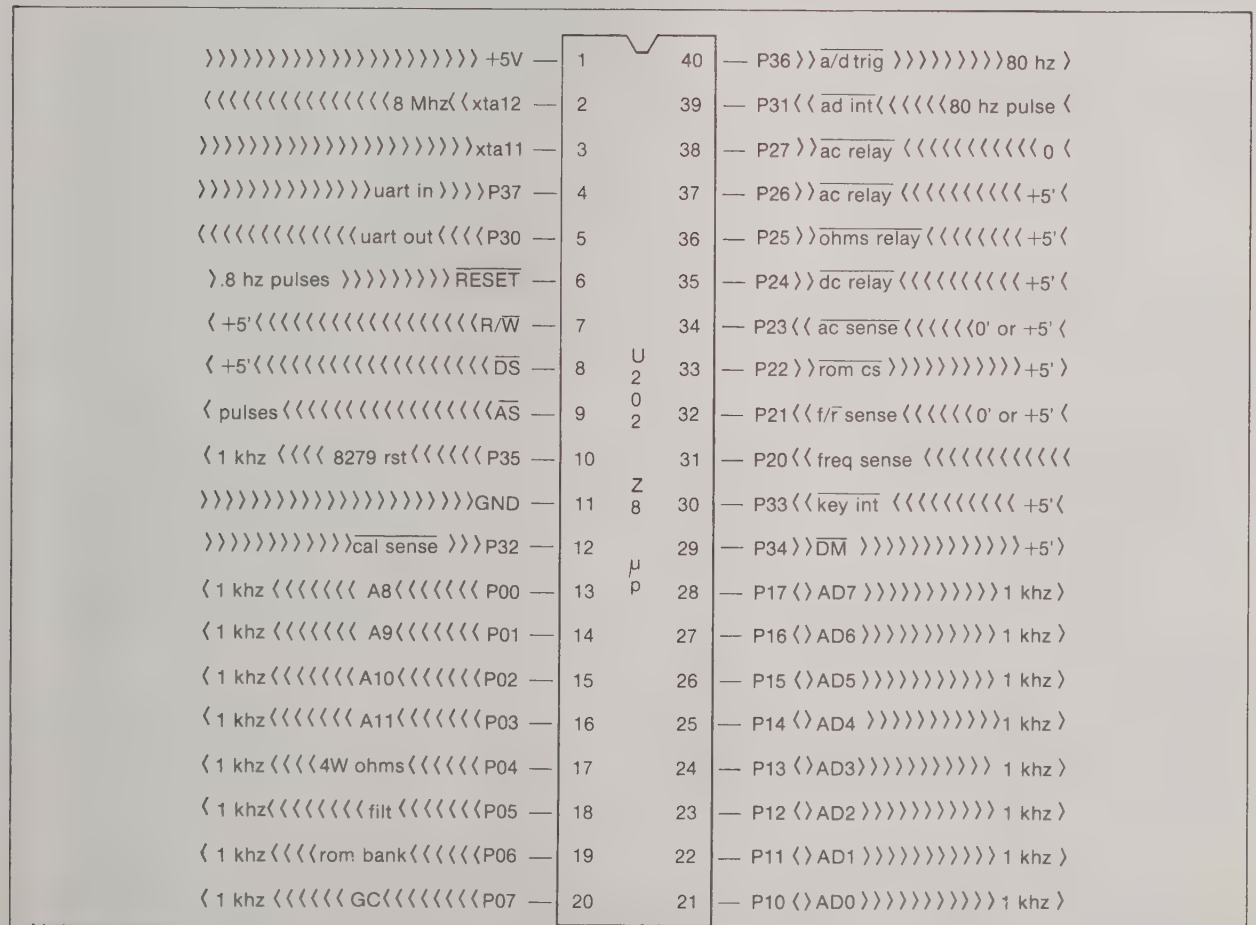
6-41. IN-GUARD MICROCOMPUTER SYSTEM

This procedure is performed entirely in the In-Guard Troubleshooting Mode. This mode is established by shorting TP205 (U202-38) to Reference Low (TP306, or the L-shaped shield around U202) prior to turning on the instrument. Refer to Figure 6-9. To maintain this mode, the short must remain in effect after the instrument is turned on. When this is done, the uC programs U202-38 as an input (it is normally an output) to preclude any possibility of damage due to the short.

CAUTION

To avoid damaging the μC, the short must be initiated before the instrument is turned on, not after.

The In-Guard Troubleshooting Mode also programs all the normal port outputs to display a 1 kHz square wave except that the IEEE-488 output (U202-4) sends the word "55" repeatedly at a rate of 2,000 words/second and the A/D trigger (U202-40) is a square wave at its normal frequency of 80 Hz, and DM and P23 stay high. (The data received at U202-5 is meaningless.) Adjacent port outputs display opposite phases of the 1 kHz square wave. All μC


+5V — 1
8 Mhz xta12 — 2
xta11 — 3
uart in P37 — 4
uart out P30 — 5
.8 hz pulses RESET — 6
+5' R/W — 7
+5' DS — 8
pulses AS — 9
1 khz 8279 rst P35 — 10
GND — 11
cal sense P32 — 12
1 khz A8 P00 — 13
1 khz A9 P01 — 14
1 khz A10 P02 — 15
1 khz A11 P03 — 16
1 khz 4W ohms P04 — 17
1 khz filt P05 — 18
1 khz rom bank P06 — 19
1 khz GC P07 — 20
U202 Z8 µp
40 — P36 a/d trig 80 hz
39 — P31 ad int 80 hz pulse
38 — P27 ac relay 0
37 — P26 ac relay +5'
36 — P25 ohms relay +5'
35 — P24 dc relay +5'
34 — P23 ac sense 0' or +5'
33 — P22 rom cs +5'
32 — P21 f/r sense 0' or +5'
31 — P20 freq sense
30 — P33 key int +5'
29 — P34 DM +5'
28 — P17 AD7 1 khz
27 — P16 AD6 1 khz
26 — P15 AD5 1 khz
25 — P14 AD4 1 khz
24 — P13 AD3 1 khz
23 — P12 AD2 1 khz
22 — P11 AD1 1 khz
21 — P10 AD0 1 khz

Notes on use.

Closest to the z8 is the z8 pin definition.
Next out is the normal use definition.
Next out is the signal that should be present during in-guard troubleshooting mode.
0' is TTL low (< .8v). +5' is TTL high (> 2.4v).

Figure 6-9. U202 Pin Diagram

pins that are normally only programmed as inputs are also programmed as inputs to prevent contentions between them and the outputs from other ICs which drive them. Data coming into all μC inputs (except pin 38) is ignored.

NOTE

If the A/D IC (U101) is working properly, its watchdog timer briefly interrupts all of the In-Guard Troubleshooting Mode signals every 1.5 sec for a period of about 0.2 sec. (The signals are then re-established.) If this occurs, the main counter in U101 and its watchdog timer are operating correctly. (See step 6, below.)

When the test is complete, turn off the 8840A and remove the short from TP205.

6-42. In-Guard Microcomputer

While the 8840A is in the In-Guard Troubleshooting Mode, check the following in the order shown:

1. Power supplies: +5V dc at U202-1; 0V dc U202-11.
2. μC clock output: 8 MHz at U202-2,-3.
3. Trigger line U202-40 (TP201): Square wave, 50% duty, low 0V, high 3.8V (nominal). The period of the trigger signal should be 12.500 ms for 60 Hz line.
4. Interrupt from A/D (U202-39): Normally low, duration 48 us occurs approximately 5450 us after falling edge of trigger signal on TP201 (U202-40).
5. Guard-crossing test pattern (U202-4): Waveform C (see Figure 6-10).
6. Interrupts from watchdog timer (U202-6): Pulsed low for 0.2 sec every 1.5 sec, exponential rise between pulses.
7. Output test patterns (see Waveforms A and B in Figure 6-10): 1 kHz square wave on indicated pins, 50% duty cycle, low 0V, high 3.8V nominal. (The waveforms are interrupted every 1.5 sec for 0.2 sec due to interrupts from the watchdog timer.) To observe these patterns, remove U220, attach a logic clip to address latch U219 and sync on U219-3 for Reference Waveform A on channel 1 of a dual trace scope.

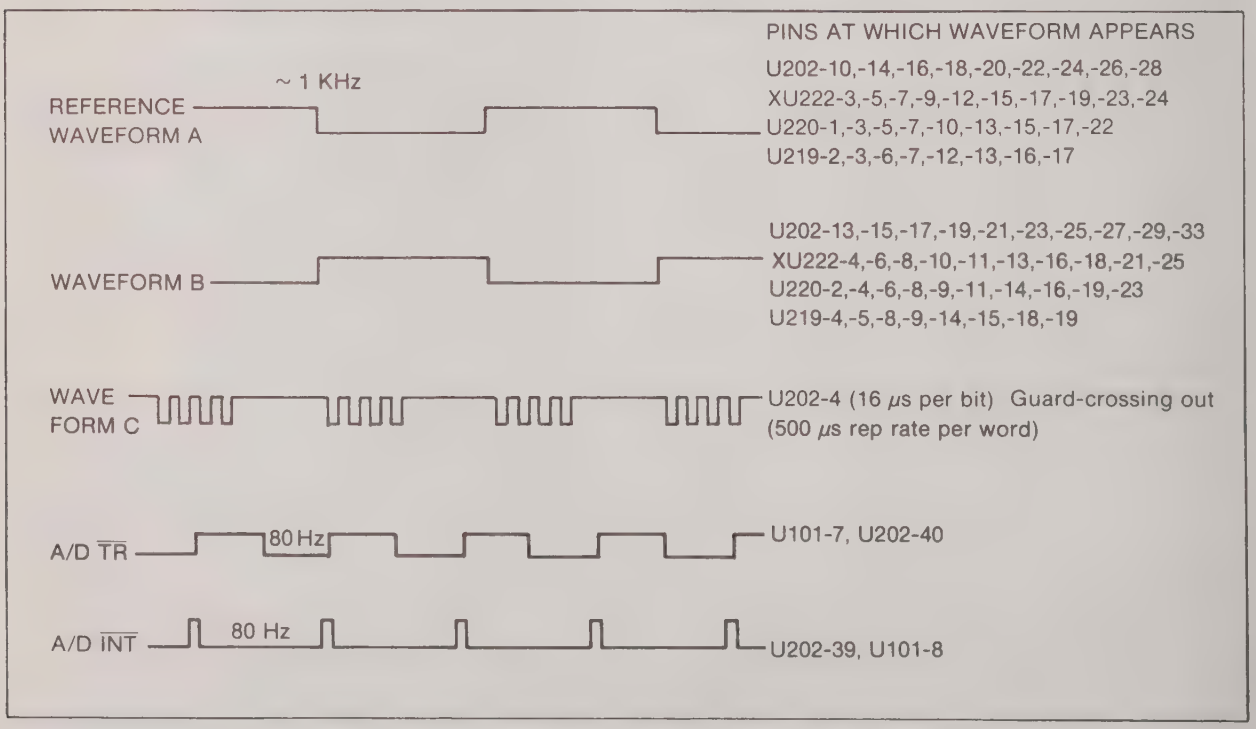


Figure 6-10. Waveforms for In-Guard Troubleshooting Mode

Compare channel 1 with waveforms at U202-10,-14,-16,-18,-20,-22,-24,-26,-28. These should all be the same as reference Waveform A (including phase). Then compare channel 1 with waveforms at U202-13,-15,-17,-19,-21,-23,-25,-27,-29,-33. These should be the same as Waveform B, which is simply the opposite phase of Waveform A.

6-43. Address Latch (U219)

Verify that U219-2,-6,-7,-12,-13,-16,-17 are the same as Waveform A (see Figure 6-10) on U219-3. Verify that U219-4,-5,-8,-9,-14,-15,-18,-19 are the same as Waveform B. The waveforms should be interrupted every 1.5 sec for 0.2 sec due to interrupts from the watchdog timer.

6-44. External Program Memory (XU222)

Sync on U219-3. Verify that XU222-3,-5,-9,-12,-15,-17,-19,-23,-24 are the same as Waveform A (see Figure 6-10) on U219-3. Verify that XU222-4,-6,-8,-10,-11,-13,-16,-18,-21,-25 are the same as Waveform B. The waveforms should be interrupted every 1.5 sec for 0.2 sec due to interrupts from the watchdog timer. (Note: XU222 pins refer to a 28-pin socket.)

6-45. Calibration Memory (U220)

Sync on U219-3. Verify that U220-1,-3,-5,-7,-10,-13,-15,-17,-22 are the same as Waveform A (U219-3). Verify that U220-2,-4,-6,-8,-9,-11,-14,-16,-19,-23 are the same as Waveform B. The waveforms should be interrupted every 1.5 sec for 0.2 sec due to interrupts from the watchdog timer.

6-46. Relay Buffer (U201)

At this point it is necessary to return the 8840A to the normal operating mode by turning the power switch off, removing the short from TP205 (U202-38), and installing the True RMS AC option, if present, so that U201 -14, -15 may be checked. Power up the instrument. Unlike the previous checks, outputs are steady state and therefore do not require a sync signal. Logic "1" is approximately 4.3V dc.

Check that U201-14 is high (4.3V) for mA AC and all ranges of VAC, and low for all other functions.

Check that U201-15 is high (4.3V) for mA AC and 200V ac and 700V ac ranges, and low for all other functions.

Check that U201-16 is high (4.3V) for all 2-wire and 4-wire ohms ranges, and low for all other functions.

Check that U201-17 is high (4.3V) for the lowest three VDC ranges and all 2-wire and 4-wire ohms ranges, and low for all other functions.

6-47. 3-to-8 Chip Select Decoder (U208)

Make the following checks in the normal operating mode using the fast reading rate and any function and range. These sequences begin 5.5 ms after the A/D trigger, which is the falling edge at U202-40.

Check U208-13 for 0.2 us pulses, normally high, groups of 1, pulse spacing: 10 ms.

Check U208-12 for 0.2 us pulses, normally high, groups of 1, pulse spacing: 10 ms (10 us after pin 13).

Check U208-11 for 0.2 us pulses, normally high, groups of 1, pulse spacing: 10 ms (46 us after pin 13).

Check U208-15 for 0.2 us pulses, normally high, groups of 13, group width: 100 us, group spacing: 10 ms (230 us after pin 13).

Check U208-7 for 0.6 us pulses, normally high, groups of 5, group width: 50 us, group spacing: 10 ms (380 us after pin 13).

This concludes testing of the basic μC system. If the keyboard or display is still suspect at this point, proceed to Display System, below. Otherwise proceed to Analog Control Signals, below.

6-48. DISPLAY SYSTEM

The display/keyboard system is operated by a complex LSI IC (U212). Generally, this IC is checked indirectly by observing behavior of the simpler logic devices which it drives.

If the keyboard is working at all, the 8840A display should be "frozen" to make the following tests. This places the 8840A in a special display test configuration. If it is not possible to freeze the display, it should still be possible to observe the waveforms at U215, U213, U221, and U211 as described in the following paragraphs.

To freeze the display, turn off the instrument, press the POWER switch and within 1 second press the SRQ button. If all is well, all display segments will light and remain lit. Do not press any other buttons as that will release the display, allowing the instrument to resume its normal power-up sequence. This state should remain in effect for all of the following tests.

6-49. Display Control (U212)

Check for the 1 MHz clock from the A/D IC at U212-3.

NOTE

The following waveforms are illustrated in Figure 6-11.

6-50. 8-Bit Digit Driver (U215)

Check for strobe waveforms 0-7 on U215-8,-1. Reference U215-8 for waveform STROBE ZERO. U215-7 is STROBE ONE, U215-6 is STROBE TWO etc. High level is 3.8V to 4.3V and low is near 0V.

Check for the same waveforms at outputs U215-11 through U215-18. (However, the high level should be approximately 30V.) If these waveforms are OK, then strobe decoder U213 and display control U212 are OK in this regard.

6-51. 3-to-8 Strobe Decoder (U213)

Check for strobe waveforms 0-7 on U213-4,-5,-6,-7,-9,-10,-11,-12. Reference U213-4 for STROBE ZERO. Check for strobe decoder inputs SL0, SL1, SL2 on U213-1,-2,-3 respectively.

6-52. 8-Bit Segment Driver (U217)

Check that U217-1 through U217-7 all look like the waveform DIGIT DATA. High level is 3.8V to 4.3V.

Check that U217-12 through U217-18 all look like the waveform DIGIT DATA except high level is approximately 30V.

6-53. 4-to-7 Segment Decoder (U216)

Check that U216-1,-2,-7 are low and U216-4,-6 and U216-9 through U216-15 look like the DIGIT DATA waveform.

6-54. 8-Bit Digit Driver (U218)

Check that U218-1 through U218-4 all look like the waveform DIGIT DATA. High level is 3.8V to 4.3V.

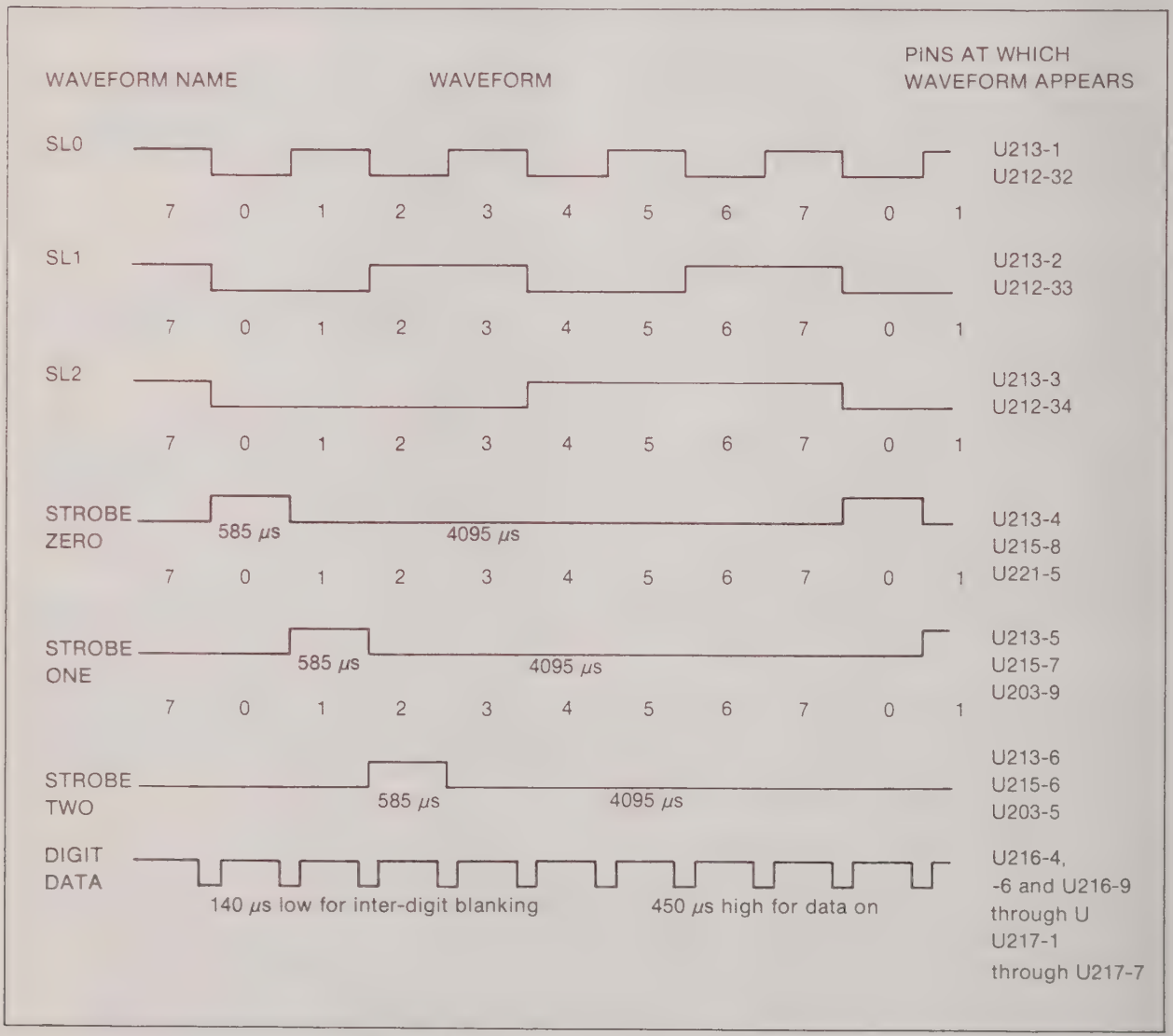


Figure 6-11. Waveforms for Display Logic

Check that U218-15 through U218-18 all look like the waveform DIGIT DATA, except that the high level should be approximately 30V.

6-55. Hex Inverter (U203)

At this point the display should be "unfrozen" by pressing any button. The instrument should then complete the power-up self-test and begin normal operation. Then do the following:

1. Check that U203-9 is the same as STROBE ONE and that U203-10 is STROBE ONE inverted.

2. Check that U203-5 is the same as STROBE TWO and that U203-6 is STROBE TWO inverted.

3. Check that U203-11 shows positive pulses 50 us to 300 us while repeatedly pushing front panel buttons in normal mode and that U203-10 shows the inverse.

4. Check that the waveform seen at U208-15 is the same at U203-13,-4 and inverted at U203-3,-12

6-56. Hex Inverter (U221)

Check that U221-5 is the same as STROBE ZERO and that U221-6 is STROBE ZERO inverted.

6-57. Quad OR Gate (U211)

Check U211-6 for 0.2 us pulses, normally high, in two groups of 3 and 15, group widths: 50 and 100 us, group spacing: 10 ms (in fast reading rate).

Check U211-8 for 0.4 us pulses, normally high, groups of hundreds, group widths: 3.5-4 ms, group spacing: about 8 ms (variable).

6-58. Keyboard Wiring

Table 6-19 indicates which waveforms in Figure 6-11 are seen on keyboard inputs to U212 when each front panel button is pressed and held. For example, if the SRQ button is pressed and held, an inverted version of STROBE ZERO waveform is applied to U212-38. If range button "20" is pressed then inverted STROBE ONE is applied to U212-1, and so forth. Note that these waveforms are very noisy with many spikes. That is normal. Compare these waveforms with normal STROBE ZERO at U215-8.

6-59. Analog Control Signals

Table 6-20 is useful for determining whether the correct digital signals are being applied to the analog control devices indicated. Since most of these devices (the quad analog switches in particular) have no digital outputs, it cannot be determined directly whether the correct pattern is being latched. That determination must be made indirectly by analog means. Nevertheless, it is valuable to know whether the correct digital signals are reaching those devices.

Correct operation of 8-bit latch U803, situated on the True RMS AC PCA (Option -09 only), can be determined directly since all of its inputs and outputs are available. Again, outputs of quad analog switches U804 and U808 are not available and must be determined by analog means.

Table 6-19. Keyboard Wiring

SIGNAL NAME	PIN	BUTTONS THAT PRODUCE INVERTED STROBE ZERO	BUTTONS THAT PRODUCE INVERTED STROBE ONE	BUTTONS THAT PRODUCE INVERTED STROBE TWO
RL0	U212-38	SRQ	200Ω/mV	VDC
RL1	U212-39	LOCAL	2	VAC
RL2	U212-1	RATE	20	2 WIRE kΩ
RL3	U212-2	OFFSET	200	4 WIRE kΩ
RL4	U212-5	AUTO	2000	mA DC
RL5	U212-6	TRIG	20M	mA AC
RL6	U212-7	EX TRIG	Not used	Not used

Table 6-20. Analog Control Devices

DEVICE	REF. DES.
Relay Buffer	U201
Quad Comparator	U305
Quad Analog Switch	U301
Quad Analog Switch	U302
Quad Analog Switch	U303
Quad Analog Switch	U402
Quad Analog Switch	U403
8-Bit Latch	U803*
Quad Analog Switch	U804*
Quad Analog Switch	U808*

*Option -09 only.

6-60. Evaluating Static Signals

Table 6-21 may be used to determine whether or not proper signals are reaching any particular analog control device. It may also be used to quickly exercise all of the devices before beginning analog troubleshooting if it is still unclear as to which devices are suspect. A number of the inputs to these devices are static which makes them particularly easy to check.

For example, suppose quad comparator U305 appears not to be working. Connect a scope to U305-11 and step the 8840A through all functions and ranges in the following sequence:

1. VDC: 200 mV, 2V, 20V, 200V, 1000V
2. VAC: 200 mV, 2V, 20V, 200V, 700V
3. 2 WIRE kΩ: 200Ω, 2k, 20k, 200k, 2M, 20M
4. 4 WIRE kΩ: 200Ω, 2k, 20k, 200k, 2M, 20M
5. mA DC (one range only)
6. mA AC (one range only)

While doing this, observe the state of U305-11. As shown in Table 6-21, this 24-range sequence will produce the following pattern at U305-11:

11010 00000 111100 111100 0 0

Next move to U305-5 and repeat. The slow reading rate gives the following pattern at U305-5:

11111 00000 111000 111000 0 0

If the instrument is not in the slow reading rate, it gives the following pattern at U305-5:

00000 00000 000000 000000 0 0

Next move to U305-7 and repeat. The pattern at U305-7 will be:

00000 00000 000000 111111 0 0

6-61. Evaluating Dynamic Signals

The procedure for evaluating the dynamic signals is only slightly more involved. For example, consider U302-7 in Table 6-21. At the right end of that row the table says to sync on U302-3. The sync pulse is negative-going. Apply it to channel 1 of a dual-trace scope sync'ing on the leading (negative-going) edge. Observe the target pin (U302-7) on channel 2 of the scope. While stepping through the 24 ranges observe the state of the target pin exactly when the sync pulse goes from low to high. (See Figure 6-12.) (This procedure works best in the fast reading rate since the repetition rate of the sync pulse on U302-3 is greater.) Using this procedure, the following pattern should be seen:

00000 11111 000000 000000 0 1

Note that the last eight rows in Table 6-21 are actually outputs of U803. Therefore, observing those pins proves not only that the control signals are correct but also that U803 itself is functioning correctly.

6-62. DC Scaling Troubleshooting

Whenever there is a failure in the DC Scaling circuit, first check the power supply voltages for all active components. (Supply voltages and pin numbers are listed in Table 6-22.) A test of the bootstrap supplies for U306 is described later under this heading.

After checking the power supplies, use an oscilloscope to check the digital logic input pins of quad analog switches U301, U302 and U303. These should show digital signals with high $\geq$+3V and low $\leq$+0.5V.

In the 20V range, any voltage applied to the HI INPUT terminal (relative to Reference Low) should be present at U306-3. If it isn't, trace the voltage from the HI INPUT terminal to U306-3 to isolate the problem.

To check U306, select the VDC function and the 2V range. Measure the voltage at TP302 while applying first 1V and then 0V (a short) across the HI and LO INPUT terminals. If 1V and then 0V appear at TP302, U306 is probably OK. If not, the problem is in U306 or its bootstrap supplies (TP301 and TP303).

To check the bootstrap supplies, put the 8840A in the 20V range and measure the voltage at TP301, TP302, and TP303. TP301 should be 6.2V (nominal) above TP302, and TP303 should be 6.2V (nominal) below TP302. If the

DEFINITIONS
s == logic "1" if in slow reading rate
f == logic "1" if in fast reading rate
f' == logic "1" if not in fast reading rate (i.e., if in slow or medium)

	uC Port	Function	Pin No.	Pack	VDC R1	VDC R2	VDC R3	VDC R4	VDC R5	VAC R1	VAC R2	VAC R3	VAC R4	VAC R5	2 WIRE kΩ R1	2 WIRE kΩ R2	2 WIRE kΩ R3	2 WIRE kΩ R4	2 WIRE kΩ R5	2 WIRE kΩ R6	4 WIRE kΩ R1	4 WIRE kΩ R2	4 WIRE kΩ R3	4 WIRE kΩ R4	4 WIRE kΩ R5	4 WIRE kΩ R6	mA DC R5	mA AC R5		
BYTE #1	P07	GC	11	U305	1	1	0	1	0	0	0	0	0	0	1	1	1	1	0	0	1	1	1	1	0	0	0	0		
	P06																													
	P05	FILT	5	LM339	s	s	s	s	s	0	0	0	0	0	s	s	s	0	0	0	s	s	s	0	0	0	0	0		
	P04	4WO	7,8		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	0	0		
	P27		5		1	1	1	1	1	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	0		
	P26		4	U201	1	1	1	1	1	1	1	1	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	0		
	P25		3	2585A	1	1	1	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	1	1		
	P24		2		0	0	0	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	1	1		
	P07	GC	1	U301	1	1	0	1	0	0	0	0	0	0	1	1	1	1	0	0	1	1	1	1	0	0	0	0		
	P07	GC	5	QAS	1	1	0	1	0	0	0	0	0	0	1	1	1	1	0	0	1	1	1	1	0	0	0	0		
	P04	4WO	9		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	0	0		
		(AD6)	7		1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0	0	1	1	1	1	1	← Sync on U301-3	
BYTE #2 CS2		(AD7)	7	U302 QAS	0	0	0	0	0	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	Sync on U302-3	
		(AD3)	9		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0		
		(AD1)	5		f	1	1	1	1	f	f	f	f	f	f	f	f	f	f	f	f	f	f	f	f	f	f	f		
		(AD0)	1		0	0	1	0	1	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	1	1	0	0		
		(AD5)	9	U303 QAS	0	1	1	1	1	1	1	1	1	1	0	1	1	1	1	1	0	1	1	1	1	1	0	1	Sync on U303-3	
		(AD4)	7		1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0	1	0		
		(AD2)	5		f'0	0	0	0	f'	f'	f'	f'	f'	f'	f'	f'	f'	f'	f'	f'	f'	f'	f'	f'	f'	f'	f'	f		
		+5V dc	1																											
BYTE #3 CS3		(AD7)	1	U402 QAS	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	0	0	0	1	1	1	0	0	Sync on U402-3	All these signals must be checked by sync'ing on the negative-going 0.2 us pulse indicated, and looking at the state of the target pin at the rising edge of the sync pulse.
		(AD6)	5		1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0	1	1	1	1	0	0	1	1		
		(AD5)	7		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1	0	0		
		(AD4)	9		1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	1	1	1	1	1	0	1	1		
		(AD3)	1	U403 QAS	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	1	1	0	0	0	Sync on U403-3	
		(AD2)	5		1	1	1	1	1	1	1	1	1	1	0	0	1	0	0	0	0	0	1	0	0	0	1	1		
		(AD1)	7		1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	1	1	1	1	1	0	1	1		
		(AD0)	9		0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	1	1	0	0	0	0	0	0		
BYTE #4 CS4		(AD7)	16	U803 LS374	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	Uncalibrated configuration	All these OUTPUTS are static
		(AD6)	19		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
		(AD5)	5		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
		(AD4)	2		0	0	0	0		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
		(AD3)	15		1	1	1	1	1	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1		
		(AD2)	6		1	1	1	1	1	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0		
		(AD1)	12		1	1	1	1	1	1	0	1	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1		
		(AD0)	9		0	0	0	0	0	1	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1		

Table 6-21. Analog Control Logic States

bootstrap supplies are operating correctly, measure the voltage at U306-3 and U306-6 for input voltages of +20V and -20V; if the voltage at U306-3 differs from U306-6, then U306 is bad.

To check the dc input path after U306, short the HI and LO INPUT terminals and read the display. If zero is displayed for ranges r3 and r5 but not for r1, r2, and r4, then the signal path including Q311 and U301B is suspect. To check Q311, apply a 1V dc input in the 2V range and check that the voltage at the drain and source of Q311 is 1V. If not, Q311 or its driver is bad. If 1V appears at U301-16, but not at the display, then U301 may be bad.

If zero is not displayed for r3 and r5 with the HI and LO INPUT terminals shorted, then Z301 or U302D is probably bad.

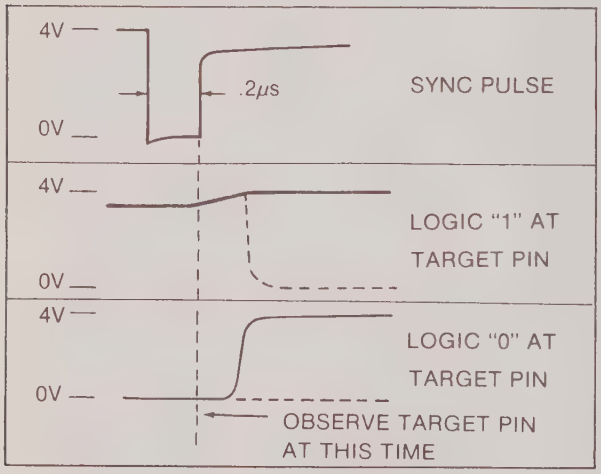


Figure 6-12. Typical Dynamic Control Signals

6-63. Track/Hold Troubleshooting

If a problem is suspected in the Track/Hold (T/H) circuit, first check the power supply voltages of all active components. (See Table 6-22.)

Next, check the T/H output waveform at TP103 with an oscilloscope. Set the 8840A to the VDC function and 2V dc range, apply +1V dc across the HI and LO INPUT terminals, and trigger the scope from the falling edge of line not-TR (TP201). The waveform should look like that in Figure 6-13. The circuit may be checked as follows:

1. Short the HI and LO INPUT terminals, and select the 2V dc range.

2. Short U301-14 to ground (Reference Low). The 8840A should read within 10 counts of zero. (The actual value is not as important as its stability.)

3. Connect U307-6 to U303-18, and monitor the voltage at TP103 using another multimeter. The 8840A should read about the same as the external multimeter, but with opposite sign.

If the 8840A fails step 2 but not step 3, then U303 is bad. If the 8840A fails both steps 2 and 3, then the fault is in the A/D Converter or the T/H Amplifier. To tell which, lift the end of R318 closest to the front panel (connected to U307-6) and apply an input of less than +2V to TP103. If the A/D Converter is OK, the 8840A will display the applied voltage with the opposite polarity. (For example, if you apply +1V, it should display -1V.) The readings may differ by a slight offset.

6-64. Ohms Current Source Troubleshooting

Malfunctions in the ohms functions can be caused by a fault in the Precision Voltage Reference, Ohms Current Source, or Ohms Protection. Malfunctions can also be caused by a fault in the DC Scaling circuit which loads the Ohms Current Source.

First check the power-supply levels (see schematic). Then check all digital logic input pins of the quad analog switches (U402 and U403). These should show digital signals with high $\geq$+3V and low $\leq$+0.5V.

To determine whether the Ohms Current Source is being loaded down by the DC Scaling circuit, select the VDC function and connect a 10 kΩ resistor between the collector of Q404 and ground (Reference Low). (Selecting the VDC function opens k401, and configures the Ohms Current Source in the 20 kΩ range.) If the voltage across the 10 kΩ resistor is 1V, then the Ohms Current Source is working (at least in the 20 kΩ range), and the problem is probably due to a defect in the DC Scaling circuit.

To test whether the Ohms Current Source is actually being sourced out the HI and LO OUTPUT terminals, select the 20 kΩ range and the 2-wire ohms function, connect a 10 kΩ resistor across the HI and LO INPUT terminals, and measure the voltage across this resistor with another voltmeter. There should be a 1V drop across the resistor.

If the ohms functions do not work in any range, check the supplies at U401 (±15V), U404 (+30V and -5V), U402 (+15V, +5V, and 0V), and U403 (+15V, +5V, and 0V), and check the -7V reference at R416. Also, test the Ohms Protection circuitry as follows: Select the 20 kΩ range and 2-wire ohms function, connect a 10 kΩ resistor to the HI and LO INPUT terminals, and bypass the protection circuitry by connecting the emitter of Q402 to the junction of R410 and R309. If a reading of 10 kΩ is displayed, the protection circuitry is defective. To isolate the problem, successively short each part of the protection circuitry that is in series with the Ohms Current Source, until the display reads 10 kΩ.

If the ohms functions work in only certain ranges, suspect resistor network Z401 or analog switches U402 or U403. To test the analog switches, select a defective range and connect a short across the switches that are supposed to be closed in that range. If the Ohms Current Source then works, one of the analog switches is probably bad. If the range still doesn't work, then Z401 is probably bad.

To test the first stage of the Ohms Current Source, short U402-19 to Reference Low through a 2 kΩ resistor and check that the voltage across R401 is 7.0V (nominal) and that the voltage at U401-6 is -4V (nominal). If the voltages are correct, the first stage of the Ohms Current Source (U401 and Q401) is working. If not, suspect U401 or Q401. (Under no circumstances should U401-6 ever be positive.)

If the first stage of the Ohms Current Source is working, test the second stage as follows:

1. Select the 20 kΩ range and apply a 10 kΩ input.
2. Check that the voltage between TP403 and U402-16 is +5V.
3. Measure the voltage at U404-6 with respect to ground. If the voltage at U404-6 is negative, U404 is bad. (Under no condition should U404-6 ever be negative.)

Table 6-22. DC Scaling and Track/Hold Supply Voltages

PIN OR DEVICE	SUPPLY VOLTAGE	PIN OR DEVICE	SUPPLY VOLTAGE
U301-6	+5V	U303-20	+7.5V
U301-10	0V	U303-11	-8.2V
U301-20	+7.5V	U304-4	-8.2V
U301-11	-5V	U304-7	+7.5V
U302-6	+5V	U305-3	+5V
U302-10	0V	U305-12	-5.5V (nominal)*
U302-20	+7.5V	U307-4	-15V
U302-11	-5V	U307-7	+15V
U303-6	+5V	Q305,c	+30V
U303-10	0V	Q306,c	-30V

*With 0V input.

6-65. Precision Voltage Reference Troubleshooting

If there is a failure of the Precision Voltage Reference, check the power supply levels at U702. U702 requires two supplies, +15V and -15V, which must be within approximately ±5% of their nominal value. Using an oscilloscope, check that the power supplies and op amp outputs (U702-1 and U702-7) are free from ripple and oscillations.

If the supplies are correct, check the output voltage levels at TP701 and TP702. The voltages should be +7.00000V ±1000 ppm and -7.00000V ±250 ppm. Also check that the reference amplifier output voltage (U702-1) is nominally +6.5V.

If the outputs are grossly out of tolerance (e.g., stuck at +15V or -15V), the most likely cause is a bad op amp (U702) or open resistor network (Z701 or Z702). If the outputs are slightly out of tolerance, the most likely cause is a defective or out-of-tolerance resistor in Z701 or Z702. Because Z701 is precisely matched with U701, Z701 and U701 must be replaced as a matched set.

Shorts between lands or runs can also cause small errors (10 ppm to several hundred ppm). Shorts between sense and output lands can cause small errors that are not related to resistor networks. Load regulation problems can also be caused by shorts between sense and load lines.

In some rare cases, the op amps (U702A and U702B) could be out of spec, causing a small error. The maximum input offset voltage of the op amps used in the circuit is 3 mV.

6-66. A/D Converter Troubleshooting

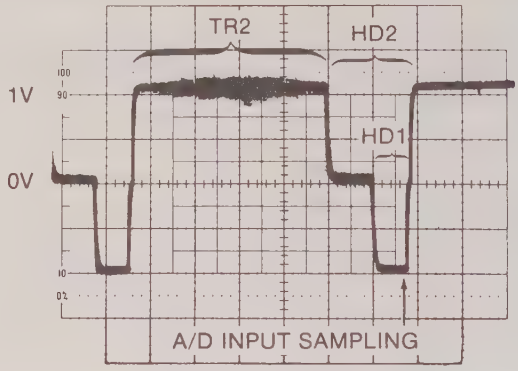
If there is a failure of the A/D Converter, all power supply levels should be checked at the op amps (U102 and U103) and the A/D IC (U101). The A/D Converter has a total of seven supplies: +15V, -15V, +5V, +7.5V, -8.2V, +7.00000V, and -7.00000V. All supplies should be within 5% of their nominal values except for the +7.00000V and -7.00000V reference supplies, which should be within ±1000 ppm and ±250 ppm respectively. The bootstrap supplies (lines BS1 and BS2) should be +7V and -7V (±10%) referenced to the + input of the A/D amplifier (U103-3).

Troubleshooting the bootstrap supplies can often be made easier by putting the 8840A in EX TRIG (to stop the A/D Converter) and connecting the input of the A/D Converter (TP103) to INPUT LO (Reference Low on the schematic). The bootstrap supplies are then referenced to instrument common (Reference Low).

NOTE

For the following tests, set the 8840A to the VDC function and the 2V range, and trigger the oscilloscope from the falling edge of line not-TR (TP201).

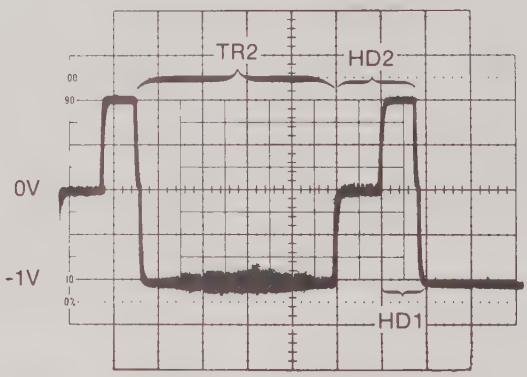
If all supplies are correct, the next most useful troubleshooting tool is the A/D output waveform at TP101, which can be checked with an oscilloscope. The waveform should look like the one shown in Figure 6-14 when the input voltage is at 50% of the selected range.



INPUT: +1V
VERT:
0.5V/DIV

HORIZ:
2 ms/DIV

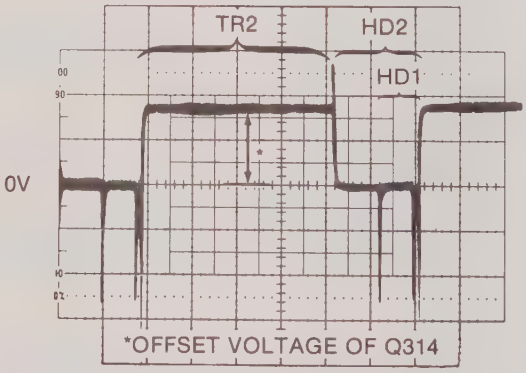
RANGE:
2V



INPUT: -1V
VERT:
0.5V/DIV

HORIZ:
2 ms/DIV

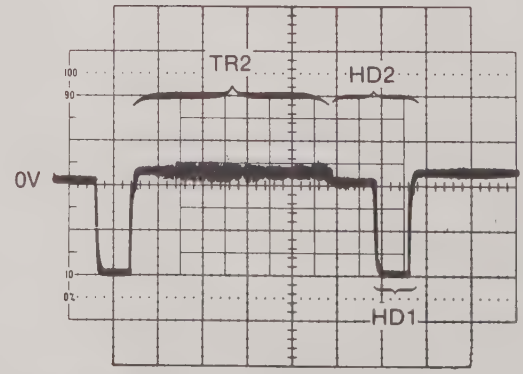
RANGE:
2V



INPUT: 0V
VERT.
5 mV/DIV

HORIZ:
2 ms/DIV

RANGE:
200 mV



INPUT:
+100 mV
VERT:
0.5V/DIV

HORIZ:
2 ms/DIV

RANGE:
200 mV

ALL WAVEFORMS FOR
SLOW READING RATE.

Figure 6-13. Typical Output Waveforms for Track/Hold Circuit (TP103)

Various portions of the waveform correspond to different parts of the A/D cycle. By examining the waveform, problems in the A/D Converter can be isolated down to one or two components.

The waveform at the storage capacitors can often be used to locate leakage problems. The leakage can be due to contamination on the Main PCA or to defective switches in U101. Figure 6-15 shows the waveforms across storage capacitors C102 and C103 (U101-24 and U101-25, respectively) for a specific input.

The A/D Converter communicates with the In-Guard μC via the internal bus, which also goes to several other sections of the instrument. What looks like a problem in the A/D Converter may actually be caused by a problem in another section of the instrument which is loading down the bus data lines (U101-1,-2,-3,-38,-39,-40). A typical waveform at one of the data lines is shown in Figure 6-16. One of the data lines can be loaded down so that the In-Guard μC fails to recognize data sent over that line. If so, the amplitude of the signal of the bad line would be less than 3V peak-to-peak.

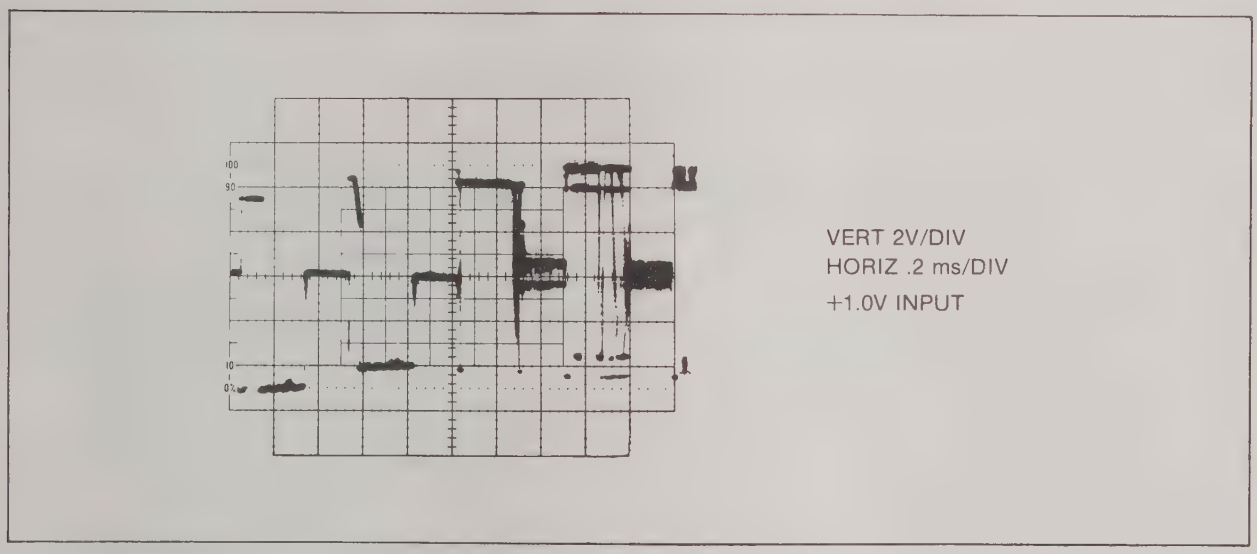


Figure 6-14. Output of A/D Amplifier (TP101)

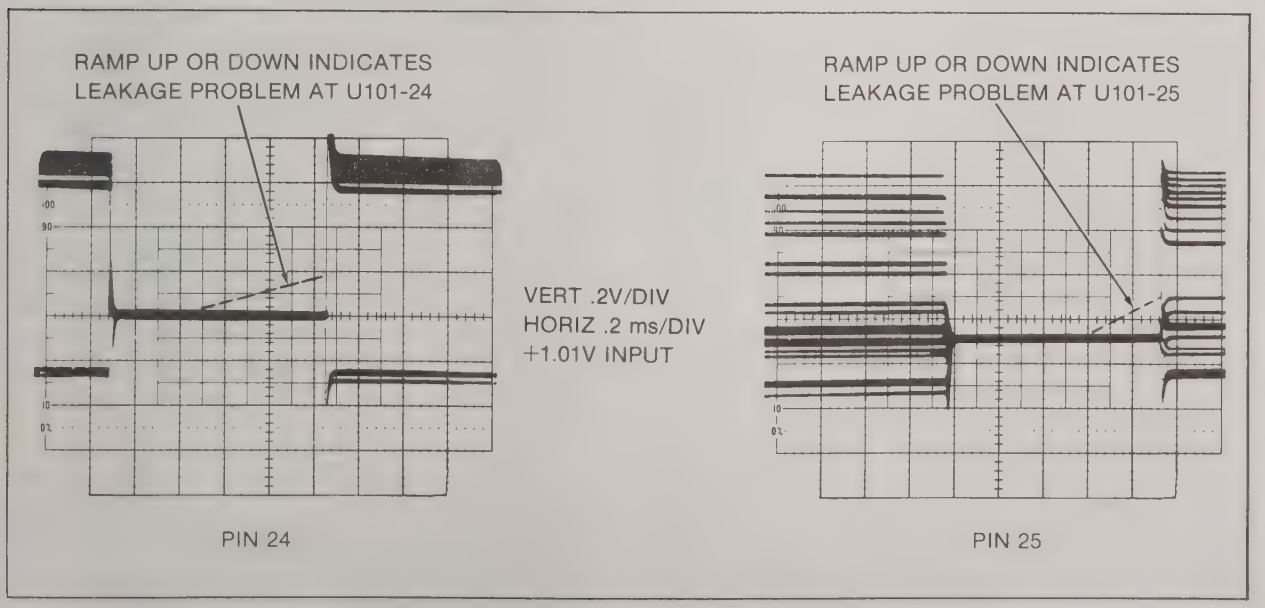


Figure 6-15. Waveforms at U101-24 and U101-25

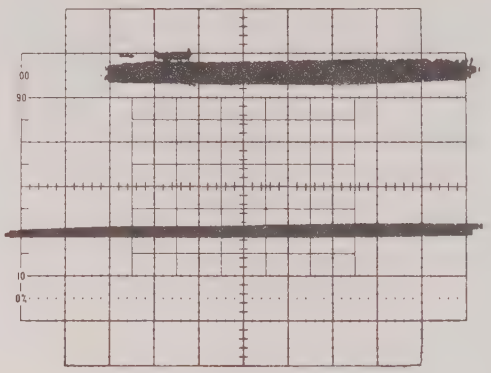


Figure 6-16. Typical Bus Data Line Waveform

One technique of finding an overloaded or shorted data line is to remove the In-Guard uC and drive one data line at a time through a 1 kΩ resistor. Measure the voltage drop across a length of the line. Normally the voltage drop across the line is zero volts (less than 5 μV). Voltage drops larger than 5 μV indicate a short. (The voltage drop is caused by excessive current flowing through the line.)

When troubleshooting the A/D Converter it may be desirable to determine what the reading is at the A/D Converter when the display is definitely incorrect. A digital problem between the A/D Converter and the In-Guard μC can cause erroneous or noisy readings or offsets. Similar problems may be caused by a failure of the Calibration Memory (U220) or by bad A/D calibration constants. (To check for bad A/D calibration constants, clear the calibration memory.)

Readings at the A/D Converter can be determined by interpreting the waveform at the DAC output (TP102). Waveforms at TP102 for several input levels are shown in Figure 6-18. The A/D reading can be calculated by knowing the weight of each bit and by weighting each nibble correctly. (The first nibble is weighted 1, the second $1/16$, the third $1/16^2$, the fourth $1/16^3$, etc.) Figure 6-18 shows how to read the A/D output for an input of 0.66V by interpreting the waveform at TP102 using the first three nibbles.

Troubleshooting the A/D Converter for defective components can be simplified by setting the circuit in a quiescent state. This can be done by selecting EX TRIG, which causes all A/D activity to stop. The A/D Converter is then in the autozero configuration, and the offset of the amplifiers and the various levels in the bootstrap circuits can be easily measured with a voltmeter. Oscillations at the outputs of the amplifiers and other abnormal signals can easily be identified with an oscilloscope.

6-67. Power Supply Troubleshooting

If the display does not light up, first check the following:

1. Is the instrument plugged in to an energized outlet providing alternating current at a frequency of 47 Hz to 440 Hz and a voltage within ±10% of that selected by the rear panel line voltage selection switches?
2. Is the POWER switch ON (pushed in)?
3. Is the rear panel fuse blown?

CAUTION

For fire protection, use exact fuse replacement only.

If the rear panel fuse is blown, replace it with a 250V fuse of the proper rating for the line voltage selected. Use 1/4A slow-blow for 100V and 120V power-line voltage and 1/8A slow-blow for 200V and 240V power-line voltage. If the fuse keeps blowing, measure the resistances of the power transformer (T601) windings. They should be within 10% of the values shown on the schematic. If not, the transformer is probably shorted. Also inspect the area around the transformer POWER switch and power-cord connector to make sure there isn't something shorting out the traces. If the IEEE-488 Interface board is suspected of causing the problem, it can easily be unplugged. Check the crowbar circuit (CR615 and Q601). If either component is shorted or if there is a large amount of leakage around or through CR615, fuses will continue to blow.

If everything looks OK but the fuse keeps blowing, troubleshooting may be performed by powering the instrument through a variac, applying only enough line voltage to find the problem without blowing the fuse. NEVER USE A LARGER FUSE. To do so will only turn a small problem into a big one.

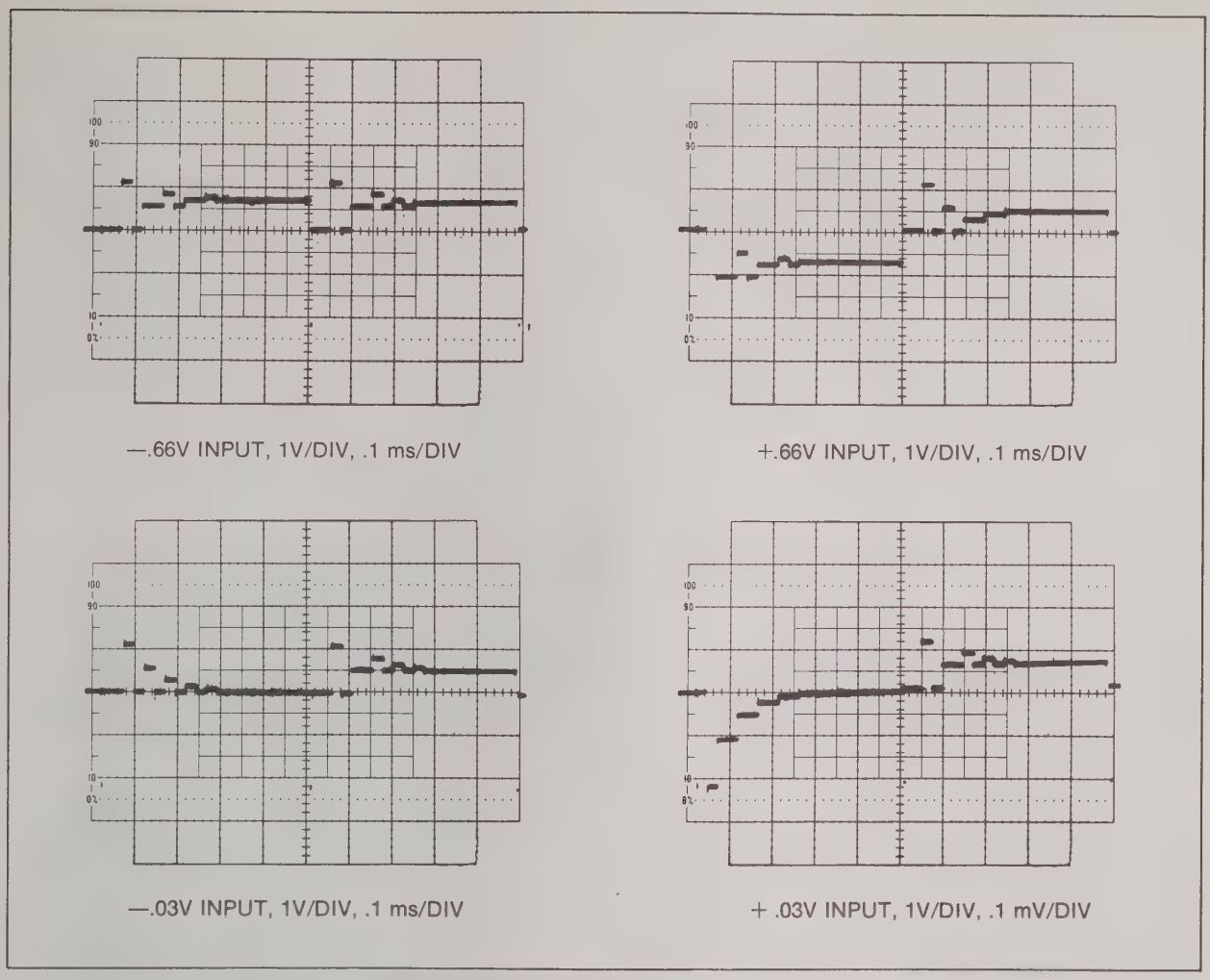


Figure 6-17. Waveforms at TP102 for Several Inputs on 2V DV Range

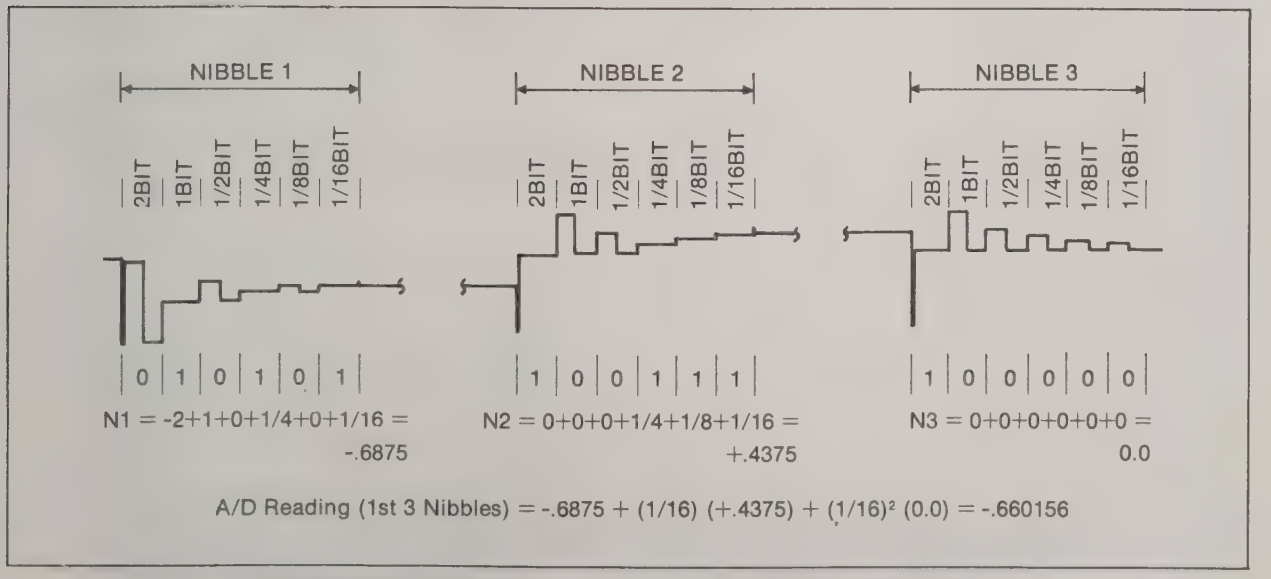


Figure 6-18. Calculating the A/D Reading From TP102 Waveform

Since power supply problems can produce symptoms in many different sections of the instrument, the first step in troubleshooting any problem should usually be a quick check of the power supplies. For each power supply (TP801-TP806), check the level with a voltmeter and check for ripple with an ac-coupled oscilloscope. The dc voltages should be within the limits given in Table 6-23.

Table 6-23. Power Supply Voltages

TEST POINT	LIMITS (in volts)	
	MINIMUM	MAXIMUM
+5V	4.75	5.25
+7.5V	7.00	7.87
+15V	14.25	15.75
+30V	28.45	31.55
-8.2	-8.61	-7.60
-15V	-15.75	-14.25
-30V	-31.55	-28.45

If a supply is too high, either its three-terminal regulator has failed or a fault elsewhere in the instrument has shorted two supplies together. After repairing such a problem, make certain that nothing else was damaged by the overvoltage.

If a supply is too low, there are a number of possible causes. First check the input to the affected regulator. If it is not at least 1V above the maximum output given in Table 6-23, the cause may be a bad transformer winding (check the resistance), open or shorted rectifiers, a shorted filter capacitor, or a shorted regulator. The latter two failures will usually blow the line fuse.

All regulators incorporate current-limiting which allows them to shut down in the event of a load failure. Therefore if the power supply output is too low, the first step should be to determine if it is due to a high load caused by a failure elsewhere in the instrument. Frequently the faulty component can be found by using a multimeter with at least 5 digits resolution to check the supply pins of all components powered from that supply. Connect one lead of the voltmeter to the appropriate test point for the power supply under test and use the other lead to probe the loads. Small voltage drops across the PCA traces can be detected in this way, and the fault isolated. If any component other than one of the regulators is too hot to touch, there is something wrong with it or with something connected to it.

The True RMS AC PCA, if installed, uses +5V and ±15V. If there is a problem with one of those supplies, first disconnect the True RMS AC PCA. If the problem goes away, troubleshoot the True RMS AC PCA using the procedure given later in this section.

With most power supply problems, the output voltage is too low or too high. More subtle problems that may be encountered include high ripple or oscillation. If more than 10 mV of line-frequency ripple exists on one of the power supply outputs, it is usually caused by the input being too low, causing the regulator to drop out of regulation. It is also possible (but not likely) that the regulator itself is defective. High-frequency oscillation (frequently synchronized with the 1 Mhz or 8 Mhz clock) is usually the result of a bad regulator or output bypass capacitor. A fair amount of high-frequency noise is generally present on all the supplies, particularly +5V, and should not cause any concern unless the instrument behaves erratically or the reading is noisy.

6-68. IEEE-488 Interface Troubleshooting (Option -05)

6-69. SERVICE POSITION

To provide easy access to the IEEE-488 Interface PCA and the Main PCA, the IEEE-488 Interface PCA can be placed in the specially provided service position as follows:

1. Remove the case from the chassis according to the Case Disassembly procedure provided earlier in this section.

2. Release the two nylon latches that hold the IEEE-488 Interface PCA in place by pulling the latches upward.

3. Position the IEEE-488 Interface PCA vertically as shown in Figure 6-19 and latch it in place be pressing the two nylon latches into the mounting supports specially provided on the chassis.

6-70. DIAGNOSTIC PROGRAM

To facilitate troubleshooting, the IEEE-488 Interface provides a diagnostic program which places the instrument in known configurations. To initiate the diagnostic program, proceed as follows:

CAUTION

To avoid damage to the 8840A or other equipment, the 8840A must be disconnected from all other IEEE-488 interface instruments while the diagnostic program is running.

1. Ensure the 8840A POWER switch is OFF.

2. Disconnect all cables from the rear panel IEEE-488 connector.

3. Short TP904 to TP905.

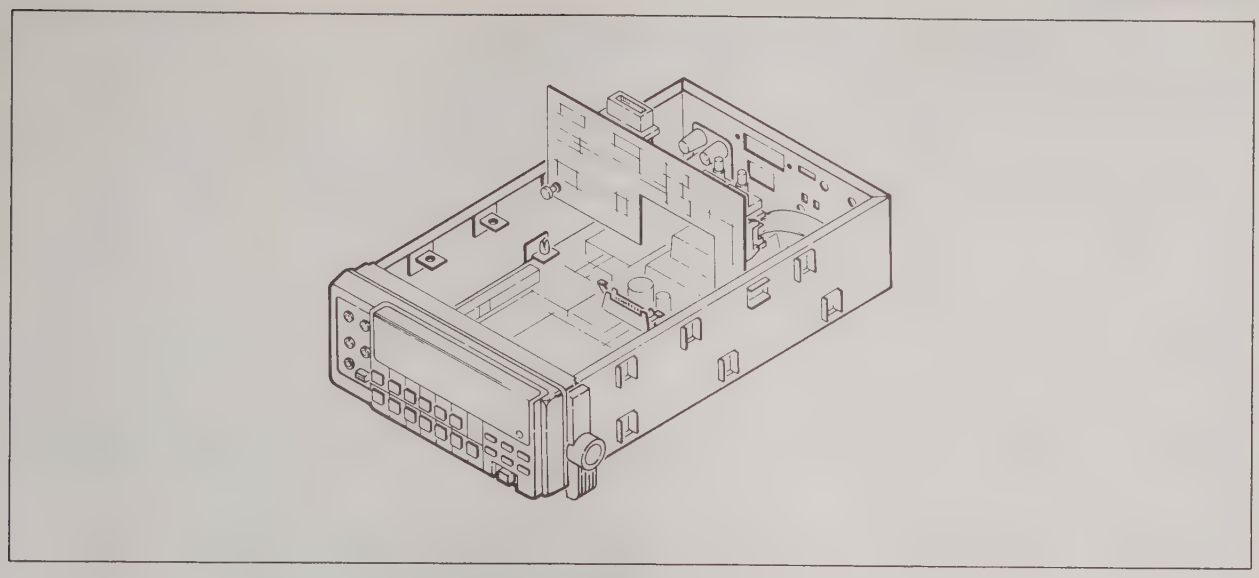


Figure 6-19. Option -05 Service Position

4. Power up the 8840A. The 8840A should display ERROR 50. To exit the troubleshooting mode, open the jumper and cycle the POWER switch from off to on.

Once the diagnostic program is started, rear-panel IEEE-488 address switches A3, A2, and A1 can be used to select one of six diagnostic modes, as shown in Table 6-24. In this table, Configuration A and Configuration B indicate which Out-Guard μC I/O port bits are programmed as outputs and driven with a signal, as shown in Table 6-25.

6-71. True RMS AC Troubleshooting (Option -09)

6-72. SERVICE POSITION

To provide easy access to the True RMS AC PCA and the Main PCA, the True RMS AC PCA can be placed in the specially provided service position as follows:

1. Remove the case from the chassis using the Case Disassembly procedure provided earlier in this section.

2. Release the four nylon latches that hold the True RMS AC PCA in place by pulling the latches upward. (See Figure 809-1E in Section 8.)

3. Disconnect the red ac input lead from both the True RMS AC PCA and the Main PCA.

4. Position the True RMS AC PCA vertically as shown in Figure 6-20 and latch it in place by pressing the bottom two nylon latches into the specially provided mounting supports on the chassis.

5. Connect the Main PCA ac take-off point (stud connector W301) to the True RMS AC PCA input (the stud connector labeled AC IN) with a 6-inch jumper (E-Z-Hook 204-6W-S or equivalent).

6-73. MAJOR PROBLEMS

The signal flow through the True RMS AC option is straightforward, with no feedback paths between individual stages. This simplifies troubleshooting and often makes it possible to isolate a single defective stage without removing the instrument cover.

Test the mid-frequency response of the VAC function around 1 kHz. If an accurate reading can be obtained on at least one range, the rms converter (U802) is working properly. Test the high-frequency response around 100 kHz. If, after calibration, an accurate reading can be obtained on at least one range, the digitally controlled filter (U801, U808, R832, and C826-829) is OK. If some ranges are good and others are bad, the defective stage may be isolated using Table 6-26. If this table is used, the bad ranges must correspond exactly to the ranges listed in the first column and all other ranges must be good.

Most ac troubleshooting can be performed with the shields removed. To remove both shields, unscrew the Phillips screw on the back of the True RMS AC PCA. The only time it should be necessary to work on the PCA with the shields in place is when there is subtle high-frequency (>20 kHz) or low-level (<10 mV) error. In that case, the PCA should be left in its operating position, and the test points probed from the foil side of the PCA. Test points are labeled on both sides to facilitate such troubleshooting.

Table 6-24. Diagnostic Modes

SWITCHES			CONFIGURATION
A3	A2	A1	
1	0	1	Static, Configuration A; odd-port bits = 1, even-port bits = 0
1	1	1	Static, Configuration A; odd-port bits = 0, even-port bits = 1
0	0	1	Static, Configuration B; odd-port bits = 1, even-port bits = 0
0	1	1	Static, Configuration B; odd-port bits = 0, even-port bits = 1
1	x	0	Dynamic, Configuration A
0	x	0	Dynamic, Configuration B

NOTES:

- "x" means switch setting does not matter.
- "Static" means the Out-Guard μC I/O port bits programmed as outputs are driven to a constant logic 1 or 0 level (as defined by switch A2).
- "Dynamic" means the Out-Guard μC I/O port bits programmed as outputs are driven with a 610 Hz, 50% duty cycle square wave. All odd port bit numbers are 180 degrees out of phase with even port bit numbers.
- "Configuration A" and "Configuration B" indicate which Out-Guard μC I/O port bits are programmed as outputs and driven with a signal, as shown in Table 6-25.

Table 6-25. I/O Port Configurations

PORT BIT	CONFIGURATION		PORT BIT	CONFIGURATION	
	A	B		A	B
P0-0	INPUT	INPUT	P1-0	OUTPUT	INPUT
P0-1	INPUT	INPUT	P1-1	OUTPUT	INPUT
P0-2	INPUT	INPUT	P1-2	OUTPUT	INPUT
P0-3	INPUT	INPUT	P1-3	OUTPUT	INPUT
P0-4	INPUT	INPUT	P1-4	OUTPUT	INPUT
P0-5	INPUT	INPUT	P1-5	OUTPUT	INPUT
P0-6	INPUT	INPUT	P1-6	OUTPUT	INPUT
P0-7	INPUT	INPUT	P1-7	OUTPUT	INPUT
P2-0	OUTPUT	INPUT	P3-0	INPUT	INPUT
P2-1	OUTPUT	INPUT	P3-1	INPUT	INPUT
P2-2	OUTPUT	INPUT	P3-2	INPUT	INPUT
P2-3	0	OUTPUT	P3-3	INPUT	INPUT
P2-4	1	OUTPUT	P3-4	OUTPUT	OUTPUT
P2-5	OUTPUT	INPUT	P3-5	OUTPUT	OUTPUT
P2-6	INPUT	INPUT	P3-6	OUTPUT	OUTPUT
P2-7	INPUT	INPUT	P3-7	serial	serial

NOTES:

- Due to external hardware conflicts, the following bits are NEVER driven by the Out-Guard μC in ANY diagnostic mode: P0 (all bits); P2-6,7; and P3-0,1,2,3.
- Some port bits not driven by the Out-Guard μC during a particular mode may still have a signal on them by being driven indirectly through external hardware. Example: P2-0 and P2-1 in Configuration B.
- P2-3 and P2-4 are driven with a constant logic 0 and 1 in Configuration A in all six diagnostic modes to avoid external hardware conflicts.
- P3-7 is programmed as the serial output, and constantly transmits hex 55 every 820 μs at 62,500 baud in all six diagnostic modes. This causes the front panel error message.

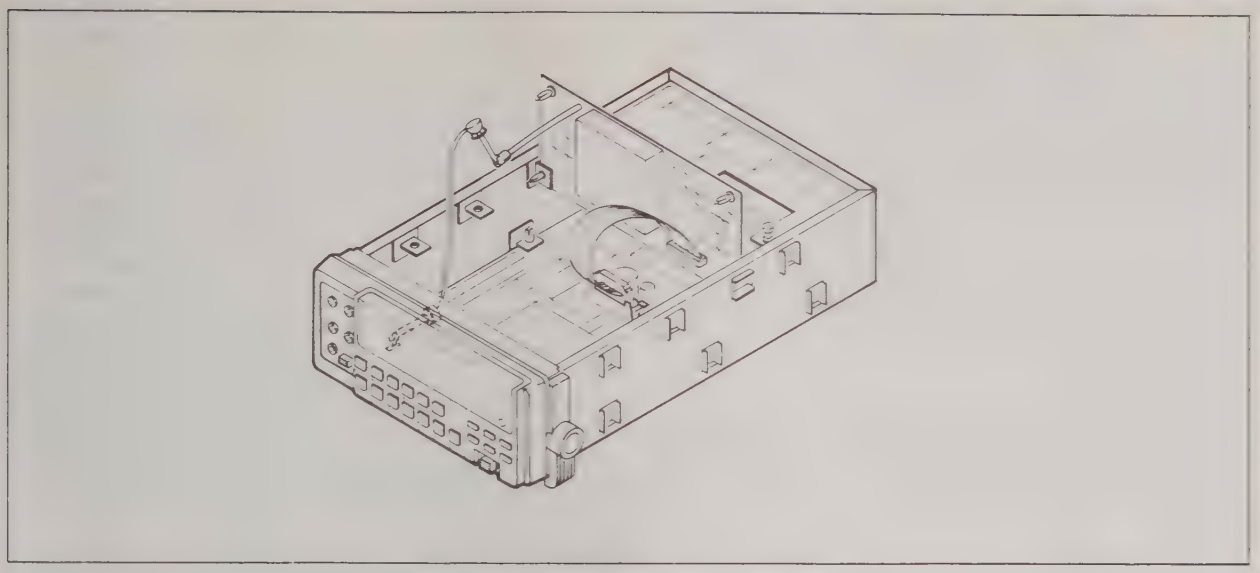


Figure 6-20. Option -09 Service Position

Table 6-26. Isolating a Defective AC Stage

DEFECTIVE RANGES	DEFECTIVE STAGE
200 mV, 2000 mA	U806B
20V, 700V	R804, R805
2V, 200V	U806A
200V, 700V	Input (Q806, K802, Z801)
2V, 20V, 200V	Input (Q806, K802, Z801)

If no ranges work, the signal should be traced from input to output. At any point where the signal disappears, the preceding stage should be searched thoroughly. To trace the signal, lock the instrument into one range (200 mV is usually a good choice) and apply the appropriate voltage shown in Table 6-27 to the HI and LO INPUT terminals. The input voltage should appear unchanged at pin Z801-1, and should appear at TP801 and TP802 as shown in Table 6-27. If no ranges work, it is likely that the rest of the scaling circuitry (U806B) is functional.

Table 6-27. AC Signal Tracing

RANGE	INPUT VOLTAGE (1 kHz)	VOLTAGE AT TP801	VOLTAGE AT TP802
200 mV	100 mV	20 mV	1V
2V	1V	200 mV	1V
20V	10V	2V	1V
200V	10V	20 mV	100 mV
700V	100V	200 mV	100 mV

If the signal at the input to U801A (pin 5) is incorrect, U804 may be defective, or the switch codes may be wrong. If the latter problem is suspected, refer to Table 6-28 and test the control lines to U804 (U804-1,8,9,16). If a logic error is found, it may be due to excessive loading or a faulty data latch (U803), or other cabling or main-board digital problems. High-frequency oscillation problems are usually caused by switches being on when they should be off, resulting in positive feedback loops being closed around portions of the scaling circuitry.

If the signal at TP802 is incorrect, but U801-5 is OK, the digitally controlled filter section (U801A and U808) is probably defective.

Table 6-28. Truth Table for U804 and K2

RANGE	PIN OR DEVICE				
	U804-1	U804-8	U80409	U804-16	K2
2000 mA	1	0	1	1	0
200 mV	1	0	0	1	0
2V	1	1	1	0	0
20V	0	1	1	1	0
200V	1	1	1	0	1
700V	0	1	1	1	1

NOTE: For U804, logic 0 = switch on. Logic 1 is >2.4V; logic 0 is <0.8V.

If the signal at TP802 is correct but the output signal (TP803) is incorrect, the rms converter is probably the source of the problem. Problems with U802 generally show up as an identical number of counts displayed in all

ranges or as an overrange in all ranges. First isolate faults in the buffer amplifier (U802A) by ascertaining that the signal at U802-13 is the same as that at TP802 when each is observed with an ac-coupled oscilloscope, and that the dc offset at U802-13 is less than 4 mV. It is possible that a component in the loop filter (U809A and associated passive components) or the post-filter (U809B and associated passive components) is defective. The dc voltage at U802-6 should be the same as that at TP803 for frequencies above 500 Hz, and should be equal to the rms value of the input signal.

6-74. MORE OBSCURE PROBLEM

Slow settling time or excessive jitter for low-frequency inputs is caused by rms converter loop errors. The cause may be a fault in the rms converter or loop filter.

If the output voltage is stuck at the supply rails, the cause is probably a fault in the rms converter. A less common cause is op amp oscillation; this can be checked with a scope at TP802.

If one or more ranges are functional but cannot be calibrated at high frequencies, then either the digitally controlled filter (U801B, R832, and C826-C829) is defective, or a defective component elsewhere in the circuit has rendered the response out of calibration range. (The high-frequency calibration is designed to cover the range of error expected due to op amp variations, input dividers, PCA tolerances, shielding, etc.). A sweep generator is useful in troubleshooting difficult frequency response problems.

The calibration control lines to U808 are set by software to store a high-frequency correction factor for each range. A state table cannot be given for these signals, but common sense will indicate if they are reasonable. For example, if all lines are at logic 0 for all ranges, something is probably wrong. Suspect U803, U808, or digital hardware on the Main PCA. If the control signals do indeed change with range, U808 or some part of the digitally controlled filter (U801B, R832, and C826-C829) may be defective. Even with the worst possible error in the high-frequency calibration code, the reading should be within 10% of the correct value at frequencies up to 100 kHz. If the error is larger, there are analog problems.

It is safe to force one control line at a time high (+5V) or low (0V) to test the individual switches in U808. (The on resistance of switches in U808 should be less than 500Ω; the off resistance should be greater than 10 MΩ.) Forcing the control lines high or low should cause the reading to change when the voltages in Table 6-27 are applied to the input terminals at 100 kHz. If only certain ranges cannot be calibrated, refer to Table 6-26 to find the suspected stage.

6-75. Guard Crossing Troubleshooting

To troubleshoot the other half of the circuit, run the diagnostic program as described under IEEE-488 Interface Troubleshooting earlier in this section. The program causes the IEEE-488 Interface PCA to send the same test pattern to the In-Guard μC. You should be able to observe the waveforms shown in Figure 6-21 at the corresponding points in this half of the circuit.

To troubleshoot the other half of the circuit, run the diagnostic program as described under IEEE-488 Interface Troubleshooting earlier in this section. The program causes the IEEE-488 Interface PCA to send the same test pattern to the In-Guard μC. You should be able to observe the waveforms shown in Figure 6-21 at the corresponding points in this half of the circuit.

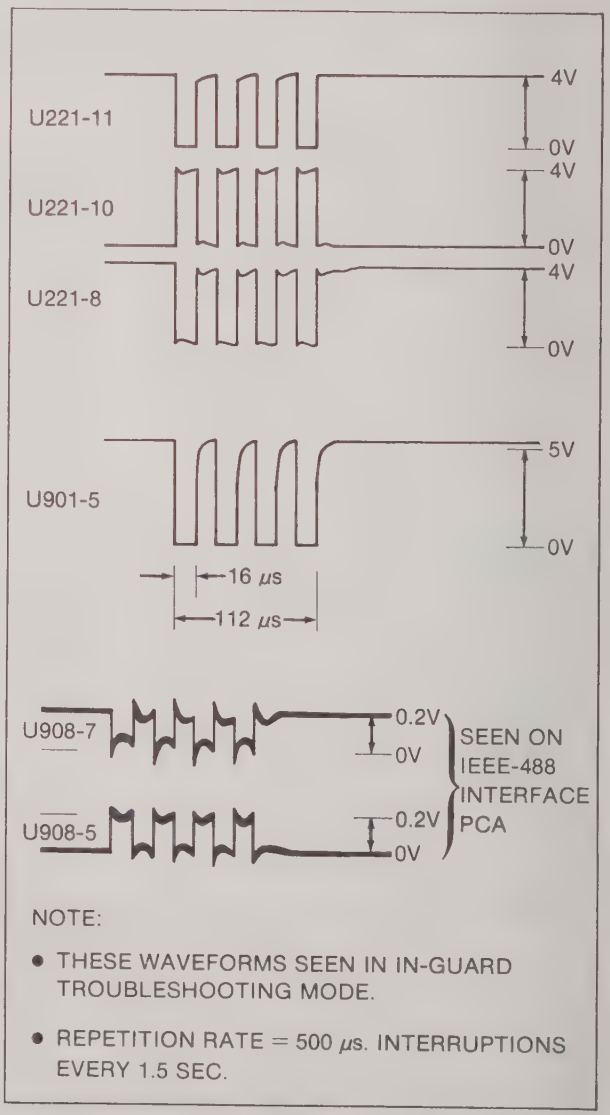


Figure 6-21. Guard Crossing Test Waveforms

6-76. INTERNAL CLEANING

CAUTION

Failures due to electrostatic discharge can be caused by improper handling of the PCAs and by the use of a vacuum cleaner with static-inducing brushes. To prevent damage by electrostatic discharge, observe the precautions described on the Static Awareness sheet in front of this section.

If visual inspection of the instrument shows excessive dirt build-up in the instrument, clean the appropriate section using clean, oil-free, low-pressure air (less than 20 psi). If necessary, remove the option PCAs first.

6-77. Cleaning Printed Circuit Assemblies

If conditions warrant, individual printed circuit assemblies (PCAs) can be cleaned with water-based commercial cleaning systems such as dishwashers. If such systems are used, observe the following precautions:

1. Remove all shield covers (applies to the True RMS AC PCA) and socketed ICs.

2. Use Reagent Grade 2 or better water (de-ionized or distilled water) for the final rinse in geographic areas with exceptionally hard water. During the final rinse, spray or run the water so that the surface is thoroughly covered to remove all ionized material.

3. Thoroughly dry all PCAs using one of the following methods:

   a. Preferably, the PCA should be dried in a low-temperature drying chamber or infrared drying rack with a temperature range of 49°C to 72°C (120°F to 160°F).

   b. If neither a drying chamber nor a drying rack is available, air dry the PCA at ambient room temperature for at least two days.

A satisfactory cleaning method consists of holding the PCAs under hot running water until they are clean. Follow this wash with a final rinse. (See consideration 2, above.)

6-78. Cleaning After Soldering

CAUTION

T.M.C. Cleaner and similar products can attack the nylon latches and other plastic pieces.

If a PCA has been soldered, it should first be cleaned with SPRAYON T.M.C Cleaner* (rosin flux remover) or equivalent. The PCA should then be cleaned with water as described above.

*Trademark of E.E. DuPont De Nemours & Co.

Section 7
List of Replaceable Parts

7-1. INTRODUCTION

This section contains an illustrated parts list for the 8840A. Similar parts lists for the options are found in Section 8. Components are listed alphanumerically by assembly and reference designation. Most listed parts are shown in an accompanying illustration.

The parts lists include the following information for each part:

1. Reference Designation.
2. Description.
3. Fluke Stock Number.
4. Federal Supply Code for Manufacturers. (See Table 7-2 for a list of names and codes.)
5. Typical Manufacturer's Part Number.
6. Total Quantity per assembly.
7. Recommended Quantity.

The REC QTY entry indicates the recommended number of spare parts necessary to support one to five instruments for a period of two years. This list presumes an availability of common electronic parts at the maintenance site. For maintenance for one year or more at an isolated site, it is recommended that at least one of each assembly in the instrument be stocked.

7-2. HOW TO OBTAIN PARTS

Components may be ordered directly from the manufacturer by using the manufacturer's part number, or from the John Fluke Mfg. Co., Inc. or its authorized representatives by using the FLUKE STOCK NUMBER.

In the event that the part you order has been replaced by a new or improved part, the replacement will be accompanied by an explanatory note and installation instructions, if necessary.

To ensure prompt and efficient handling of your order, include the following information:

1. Quantity.
2. Fluke stock number.
3. Description.
4. Reference designation.
5. Printed wire board part number and revision letter.
6. Instrument model and serial number.

A Recommended Spare Parts Kit for the 8840A is available from the factory. The Kit contains those items listed in the REC QTY column of the parts list in the quantities recommended.

Parts price information is available from the John Fluke Mfg. Co., Inc. and its authorized representatives. Prices are also available in a Fluke Replacement Parts Catalog, which is available on request.

CAUTION

*

DEVICES INDICATED BY THE ABOVE SYMBOL ARE SUBJECT TO DAMAGE BY STATIC DISCHARGE.

TABLE 7-1. 8840A DIGITAL MULTIMETER
(SEE FIGURE 7-1.)

REFERENCE DESIGNATOR A->NUMERICS--->	S	----------DESCRIPTION----------	FLUKE STOCK --NO--	MFRS SPLY CODE-	MANUFACTURERS PART NUMBER --OR GENERIC TYPE--	TOT QTY	R S -Q	N O T -E
		PCA, MAIN	728857	89536	728857	1		
		PCA, DISPLAY	728873	89536	728873	1		
AR 701	*	REF AMP SET	684209	89536	684209	1	1	
C 101-103,311		CAP,POLYPR,0.1UF,+-10%,100V	446781	55112	1.71	4		
C 104,105,205-		CAP,CER,0.22UF,+80-20%,50V,Z5U	649939	71590	CZ20	14		
C 209,304,305,			649939					
C 404,604,606,			649939					
C 609,610			649939					
C 313		CAP, CER, 10 PF +/-2% 50V	713875	71590	CN20	1		
C 202,203,617,		CAP,CER,0.01UF,+80-20%,50V,Z5V	697284	71590	2DDH61	4		
C 618			697284					
C 204,602,608,		CAP,TA,1UF,+-20%,35V	697417	05571	199D	4		
C 612			697417					
C 210		CAP,CER,1000PF,+-20%,50V,X7R	697458	71590	CW20	1		
C 301,306		CAP,POLYPR,0.22UF,+-10%,100V	446799	55112	1.71	2		
C 302		CAP,POLYPR,.33UF,+-10%,100V	520346	60935	171	1		
C 303		CAP,POLYES,0.22UF,+-5%,50V	747519	60935	185-2	1		
C 307		CAP,POLYCA,4700PF,+-10%,63V	721662	89536	721662	1		
C 308		CAP,POLYPR,0.47UF,+-10%,100V	446807	55112	1.71	1		
C 309,310		CAP,CER,120PF,+-5%,50V,COG	721142	71590	CN20	2		
C 312		CAP,POLYES,0.001UF,+-10%,50V	720938	60935	185	1		
C 314		CAP,POLYPR,0.047UF,+-10%,100V	446773	55112	1.71	1		
C 401,402		CAP,CER,330PF,+-5%,50V,COG	697441	71590	CN20	2		
C 403		CAP,POLYES,0.47UF,+-10%,50V	697409	60935	185	1		
C 601		CAP,AL,6800UF,+30-20%,16V	478784	80031	314AS752V015	1		
C 603		CAP,AL,330UF,+50-20%,100V	484436	89536	484436	1		
C 605,607		CAP,AL,470UF,+-20%,50V	747493	89536	747493	2		
C 611		CAP,AL,100UF,+50-20%,50V	649731	89536	649731	1		
C 701		CAP,CER,270PF,+-5%,50V,COG	658898	71590	CN20	1		
CL 301	*	DIODE,SI,N-JFET,CURRENT REG,20%,T&R	707836	89536	707836	1	1	
CR 101,102,201,	*	ZENER,UNCOMP, 3.9V,10%, 20.0MA, 0.4W	698654	22767	1N748A	10	1	
CR 202,306,307,	*		698654					
CR 309,311-313	*		698654					
CR 103,104,613	*	ZENER,UNCOMP, 7.5V, 5%, 20.0MA, 0.4W	698688	22767	1N755A	3	2	
CR 105,106,203-	*	DIODE,SI,BV= 75.0V,IO=150MA,500MW	698720	57668	1N4448	12	1	
CR 206,301,302,	*		698720					
CR 401,404,615,	*		698720					
CR 701	*		698720					
CR 303	*	ZENER,UNCOMP, 10.0V, 5%, 12.5MA, 0.4W	698696	22767	1N961B	1	1	
CR 304,305	*	ZENER,UNCOMP, 6.2V, 5%, 20.0MA, 0.4W	698670	22767	1N754A	2	1	
CR 308,310	*	ZENER,UNCOMP, 24.0V, 5%, 5.2MA, 0.4W	698902	22767	1N970B	2	1	
CR 402,403	*	DIODE,SI, 1K PIV, 1.0 AMP	707075	57668	1N4007	2	1	
CR 405	*	ZENER,UNCOMP,5.1V,5%,20MA,0.4W	722926	22767	1N751A	1	1	
CR 601-606,608-	*	DIODE,SI, 100 PIV, 1.0 AMP	707067	57668	1N4002	10	1	
CR 611	*		707067					
CR 607,612	*	ZENER,UNCOMP, 6.2V, 5%, 20.0MA, 0.4W	698662	22767	1N753A	2	1	
CR 614	*	ZENER,UNCOMP, 8.2V, 5%, 20.0MA, 0.4W	707539	22767	1N756A	1	1	
CR 616		ZENER,UNCOMP. 56.0V,5%,2.2MA,0.4W	187757	04713	1N979B	1		
F 301		FUSE,13/32 X 1-3/8,FAST,3A,600V	475004	71400	BBS-3	1	5	
F 302		FUSE,1/4 X 1,FAST,2A,250V	376582	71400	AGX2	1	10	
F 601		FUSE,1/4 X 1-1/4,FAST,0.25A,250V	109314	71400	AGC1-4	1	5	
F 601		FUSE,1/4 X 1-1/4,SLOW,0.25A,250V	166306	71400	MDL1-4 1	1	5	
H 1		RIVET, PLATED STEEL, .1205X5/32	103424	12014	R3647X5-32	2		
H 2		RIVET, STEEL, 7/32"HD	529941	12014	R-3479	2		
H 3		P-NUT, 4-40	380196	24347	KF2-440	1		
H 4		SCREW, PHP, STEEL, 4-40X3/16	129882	89536	129882	1		
H 5		NUT, HEX, DOUBLE CHAMFER, 4-40	184044	73734	8002A-NF	1		
H 6		SCREW,MACHINE,PHP SEMS,STEEL,6-32X3/8	177022	89536	177022	3		
H 7		GROMMET LATCH	682898	83014	HN4G-44-5	6		
H 8		PLUNGER LATCH	682906	83014	HN4P-44-4-1	6		
H 10		SPACER,HEX,THRD,BRASS,6-32X3/8	203075	89536	203075	2		
H 11		SCREW, MACHINE,PHP,STEEL,4-40X5/16	152140	89536	152140	1		
H 12		SCREW,MACHINE,PHP,STEEL,4-40X1/4	129890	73734	19022	1		
H 13		SCREW,MACHINE,THP,S STEEL,4-40X3/16	721118	89536	721118	2		
H 14		SCREW,MACHINE,FIHP,STEEL,8-32X1/2	721134	89536	721134	2		
H 15		SCREW,THD FORM,PHP,STEEL,4-20X1/2	721449	89536	721449	4		
H 16		SCREW,MACHINE,FHUP,STEEL,4-40X5/16	268193	89536	268193	2		
H 17		SCREW,MACHINE,FHUP,S STEEL,6-32X1/4	320093	89536	320093	1		
H 18		SCREW,MACHINE,FHP,STEEL,8-32X3/8	114116	89536	114116	2		
H 19		SCREW,MACHINE,PHP,S STEEL,6-32 X 5/16	424713	89536	424713	3		
H 20		SCREW,MACHINE,PHP SEMS,STEEL,4-40X3/8	281196	89536	281196	1		
H 22		NUT, 6-32 SELF-LOCKING HEX, STEEL	152819	89536	152819	1		
H 23		SCREW,MACHINE,RHS,NYLON,4-40X1/4	574780	27440	1020-004-4B	2		
H 24		SPACER	735407	89536	735407	1		
H 25		SPACER	735415	89536	735415	1		
H 26		INSULATOR	508630	89536	508630	1		

TABLE 7-1. 8840A DIGITAL MULTIMETER (CONT.)
(SEE FIGURE 7-1.)

REFERENCE DESIGNATOR A-)NUMERICS----)	S	DESCRIPTION	FLUKE STOCK --NO--	MFRS SPLY CODE--	MANUFACTURERS PART NUMBER --OR GENERIC TYPE---	TOT QTY	R S --Q	NOTE
J 201		CONNECTOR,PWB HEADER W/LATCHES 20PIN	706986	28213	3428-6302	1		
J 202		CABLE ASSY,10 COND FLAT,6"L IDC/DRB	714022	30146	1002645-C	1		
J 203,204		CABLE, DISPLAY	684167	89536	684167	2		
J 601		CONNECTOR, 3 CONTACT, MALE RECEPTACLE	461806	82389	EAC-303	1		
J 602		PIN, CONTACT, 6 PIN, #09-65-1061	380378	27264	09-65-1061	1		
JPR 1, 2		JUMPER WIRE, COPPER, NO INSULATION	643452	89536	643452	2		
K 301		RELAY,ARMATURE,2 FORM C,5VDC	615575	26806	AZ7-2C-5DE	1	1	
K 401		RELAY,REED,1 FORM A,5V,HIGH VOLTAGE	714352	71707	3400-0087	1	1	
MP 1		BRACKET, CONNECTOR MTG	534446	89536	534446	2		
MP 2		SPACER,MOUNT,NYLON	152207	07047	10123-DAP	1		
MP 3		CASE, METAL	656389	89536	656389	1		
MP 4		FRONT PANEL	656397	89536	656397	1		
MP 5		PUSHROD, POWER	656413	89536	656413	1		
MP 6		PUSH ROD RAI	656488	89536	656488	1		
MP 7		PUSH ROD CAL ENABLE SWITCH	684142	89536	684142	1		
MP 8		MOUNTING PLATE, HANDLE (LEFT)	729004	89536	729004	1		
MP 9		MOUNTING PLATE, HANDLE (RIGHT)	660472	89536	660472	1		
MP 10		HANDLE	656496	89536	656496	1		
MP 11		BEZEL,REAR	660480	89536	660480	1		
MP 12		SPACER, MATRIX	684126	89536	684126	1		
MP 13		FOOT,CASE	684183	89536	684183	2		
MP 14		INSERT, REAR PANEL	684191	89536	684191	1		
MP 15		TERMINAL BLOCK, RAI	656504	89536	656504	1		
MP 16		SEAL,CALIBRATION	735274	89536	735274	1	5	
MP 17		SUPPORT, PWB	683987	89536	683987	14		
MP 18		LENS,FRONT PANEL	656405	89536	656405	1		
MP 19		DECAL,FRONT	685081	89536	685081	1		
MP 20		DECAL, REAR	698431	89536	698431	1		
MP 22		IEEE CABLE GUIDE	728956	89536	728956	1		
MP 23		CLAMP, CABLE, 2-PIECE ASSY, 2C1-25	631507	89536	631507	2		
MP 25		SPACER, HEX	735357	89536	735357	2		
MP 26		SHIELD, SUPPORT	735308	89536	735308	4		
MP 27		FUSE HLDR,CAP,1/4 X 1-1/4 FUSE	460238	61935	031.1663	1		
MP 29		FUSE HLDR,CLIP,13/32,DIA,FUSE	516880	71400	1A1360-03	2		
MP 30		SHIELD, A/D	728907	89536	728907	1		
MP 31		PCA, SHIELD MAIN BOTTOM	728998	89536	728998	1		
MP 32		FUSE HOLDER ASSEMBLY	516039	89536	516039	1		
MP 33		HEATSINK	414128	13103	6030B-TT	1		
MP 34		CHASSIS ASSEMBLY	684134	89536	684134	1		
MP 35		FUSE HLDR,BODY,PCB	602763	82389	FAU031.3573	1		
Q 101,408	*	TRANSISTOR,SI,NPN,SMALL SIGMAL	698225	04713	2N3904RLRA2	2	1	
Q 102	*	TRANSISTOR,SI,PNP,T092	698233	04713	2N3906RLRA2	1	1	
Q 301,302,307,	*	TRANSISTOR,SI,N-JFET,LOW IGSS,RAD T&R	707703	89536	707703	10	1	
Q 308,312,313	*		707703					
Q 316,405-407	*		707703					
Q 303,304,310,	*	TRANSISTOR,SI,N-JFET,REMOTE CUTOFF	697987	89536	697987	6	1	
Q 311,315,401	*		697987					
Q 305	*	TRANSISTOR,SI,NPN,HI-VOLTAGE	722934	04713	MPSA42	1	1	
Q 306,402-404	*	TRANSISTOR,SI,PNP,SM SIG,SELECTED HFE	650846	89536	650846	4	2	
Q 309	*	TRANSISTOR,SI,NPN,SELECTD IEBO,SM SIG	685404	89536	685404	1	1	
Q 314	*	TRANSISTOR,SI,N-JFET,DUAL,TO-71	478172	32293	IT502P	1	1	
Q 601		THYRISTOR,SI,SCR,VBO=100V,0.8A	742643	89536	742643	1		
R 101,601-603		RES,CF,1K,+-5%,0.25W	573170	80031	CR251-4-5P1K	4		
R 102,203,204		RES,CF,470,+-5%,0.25W	573121	80031	CR251-4-5P470E	3		
R 103,104		RES,CF,27K,+-5%,0.25W	573477	80031	CR251-4-5P27K	2		
R 105		RES,MF,50K,+-0.1%,0.125W,25PPM	706184	09021	MF	1		
R 106		RES,CF,560,+-5%,0.25W	573147	09021	CF1/4	1		
R 201,215,217,		RES,CF,15K,+-5%,0.25W	573428	80031	CR251-4-5P15K	7		
R 305-307,604			573428					
R 202,315		RES,CF,100,+-5%,0.25W	573014	80031	CR251-4-5P100E	2		
R 205,207,208,		RES,CF,1.5K,+-5%,0.25W	573212	80031	CR251-4-5P1K5	5		
R 210,412			573212					
R 206,209,312,		RES,CF,33K,+-5%,0.25W	573485	09021	CF1/4	5		
R 313,408								
R 216,406		RES,CF,2.4K,+-5%,0.25W	573253	09021	CF1/4	2		
R 301		RES,CC,100K,+-5%,2W	285056	01121	HB1045	1		
R 302,303		RES,MF,90.9K,+-1%,0.125W,+-100PPM	720581	89536	720581	2		
R 304		RES,CF, 1.5M 5%, 1/4W	714931	09021	CF1/4	1		
R 308,316,317		RES,CF,1M,+-5%,0.25W	573691	80031	CR251-4-5P1M	3		
R 309		RES,MF,1K +/-1%,0.5W	733915	89536	733915	1		
R 310,409,415		RES,CF,5.6K,+-5%,0.25W	573337	80031	CR251-4-5P5K6	3		
R 314		RES,CC,22K,+-10%,2W	109975	01121	HB	1		

TABLE 7-1. 8840A DIGITAL MULTIMETER (CONT.)
(SEE FIGURE 7-1.)

REFERENCE DESIGNATOR A->NUMERICS---)	S	----------DESCRIPTION----------	FLUKE STOCK --NO--	MFRS SPLY CODE-	MANUFACTURERS PART NUMBER --OR GENERIC TYPE--	TOT QTY	R S -Q	NOT -E
R 318		RES,CF,620,+-5%,0.25W	641092	09021	CF1/4	1		
R 319		RES, WW, 0.1	731950	89536	731950	1		
R 321,322		RES,MF,10K,+-1%,0.125W,50PPM	706937	09021	MF	2		
R 401		RES, WW, 54.6K	730945	89536	730945	1		
R 402		RES,CF,4.3M,+-5%,0.25W	697136	09021	CF1/4	1		
R 403		RES,CF,1/4,10 M,+/-5%	696971	89536	696971	1		
R 407		RES,CF,910,+-5%,0.25W	696948	09021	CF1/4	1		
R 410		RES,WW,1K,+-10%,2W	474080	89536	474080	1		1
R 413		RES, MF, 4.99M,1/8W,0+/-100PPM	715060	09021	MF	1		
R 414		RES, MF, 576K 1%, 1/8W, 100PPM	714949	09021	MF	1		
R 416		RES,MF,100,+-1%,0.125W,25PPM	714410	09021	MF	1		
RV 301,401-404	*	VARISTOR 390V 10% RADIAL INSERTION	697383	89536	697383	6	6	
RV 601		VARISTOR,430V,20%,1.0MA	519355	09214	V275LA15AS14K275	1	1	
S 1		SWITCH,CONDUCTIVE ELASTOMERIC	680769	89536	680769	1		
S 201		SW, 2 POLE, DOUBLE THROW	473736	82389	EAC-303	1		
S 301		SW 16 POLE DOUBLE THROW	696773	71590	FBS	1		
S 601		SWITCH, ON-OFF	453605	89536	453605	1		
S 602,603		PCA, LINE VOLTAGE SELECTION SWITCH	735258	89536	735258	1		
T 201,202		TRANSFORMER, PULSE	660589	89536	660589	2		
T 601		TRANSFORMER, POWER	660548	89536	660548	1		
TM 1		OPERATOR MANUAL	684365	89536	684365	1		
TM 2		GETTING STARTED MANUAL	684373	89536	684373	1		
TP 101-103,201, TP 202,204-207, TP 301-303,403		TEST POINTS	512889 512889 512889	89536	512889	25		
U 101		IC,CMOS,RR A/D CONVERTER	715680	89536	715680	1	1	
U 102,702	*	IC,OP AMP,DUAL,LO OFFST,VOLT,LO-DRIFT	685164	12040	LF412CN	2	1	
U 103	*	IC,OP AMP,LO-OFF VOLTAGE,LO-DRIFT	685156	12040	LF411CN	1	1	
U 201	*	IC,BIPLR,8CHNL DRIVER	685412	56289	UDN2585A	1	1	
U 202	*	IC,NMOS,8 BIT MICROCOMPUTR,8840A-9002	685438	56708	Z8611PS	1	1	
U 203	*	IC,LSTTL,HEX INVERTER	393058	01295	SN74LS04N	1	1	
U 204,305	*	IC,COMPARATOR,QUAD,14 PIN DIP	387233	12040	LM339N	2	1	
U 208	*	IC,LSTTL,3-8 LINE DCDR W/ENABLE	407585	01295	SN74LS138N	1	1	
U 211	*	IC,LSTTL,QUAD 2 INPUT OR GATE	393108	01295	SN74LS32N	1	1	
U 212	*	IC,NMOS,PROGRAMBL KEYBRD/DSPLY INTRFC	685560	34649	P8279-5	1	1	
U 213	*	IC,LSTTL,8BIT ADDRSABLE LATCH,W/CLR	419242	01295	SN74LS259N	1	1	
U 215,217,218	*	IC,BIPLR,8CHNL FLOURSCNT DISPLY DRIVR	685537	56289	UND6118A-2	3	1	
U 216	*	BCD TO 7 SEGMENT DECODER/DRIVER	697730	01295	SN74LS248N	1	1	
U 219	*	IC,CMOS,OCTL D F/F W/3-STATE,+EDG TRG	585364	36665	74SC374A	1	1	
U 220	*	IC,512 X 8 EEPROM	723411	60395	X2804AD-35	1	1	
U 221	*	IC,LSTTL,HEX INVERTER W/SCHMT TRIG	483180	01295	SN74LS14N	1	1	
U 222	*	IC, 4KX8, EPROM, 8840A-4510	728964	89536	728964	1	1	
U 301-303,402, U 403	*	IC,CMOS,QUAD ANALOG SW, PLASTIC, HI.	700013 700013	89536	700013	5	10	
U 304	*	IC,OP AMP,SELECTED LO-NOISE,JFET IN	385450	12040	LH0042	1	1	
U 306	*	IC,OP AMP,SELECTED LOW VOS DRIFT,IBIAS	723361	89536	723361	1	1	
U 307	*	IC,OP AMP,JFET IN,COMPENSTD,8 PIN DIP	418780	12040	LF351	1	1	
U 401,404	*	IC,OP AMP,GENERAL PURPOSE,8 PIN DIP	478107	12040	308AN	2	1	
VR 601	*	IC,VOLT REG,FIXED,+5 VOLTS,1.5 AMPS	428847	04713	MC7805CT	1	1	
VR 602	*	IC,VOLT REG,FIXED,+24 VOLTS,1.5 AMPS	604074	04713	MC7824CT	1	1	
VR 603	*	IC,VOLT REG,FIXED,+15 VOLTS,1.5 AMPS	413187	04713	MC7815CT	1	1	
VR 604	*	IC,VOLT REG,FIXED,-15 VOLTS,1.5 AMPS	413179	04713	MC7915CP	1	1	
VR 605	*	IC,VOLT REG,FIXED,-24 VOLTS,1.5 AMPS	418251	04713	MC7924CP	1	1	
W 1		WIRE ASSY, GUARD CROSSING	684399	89536	684399	2		
W 2		WIRE ASSY, GUARD CROSSING	728840	89536	728840	2		
W 3		WIRE ASSY, GROUND	728949	89536	728949	1		
W 4		LINE CORD,3COND.FEMALE PLUG ATR.ANGLE	707018	89536	707018	1		
W 5		HARNESS, ANALOG FRONT	765297	89536	765297	1		
W 6		HARNESS, ANALOG REAR	765305	89536	765305	1		
W 7		TEST LEADS	642033	89536	642033	1		
XU 101,202		SOCKET,DIP,0.100 CTR 40 PIN	756668	89536	756668	2		
XU 211		SOCKET,DIP,0.100 CTR,28 PIN	756353	89536	756353	1		
XU 212		SOCKET,DIP,0.100 CTR,40 PIN	747170	89536	747170	2		
XU 220		SOCKET,DIP,0.100 CTR,24 PIN	756650	89536	756650	1		
Y 201	*	CRYSTAL,8.00MHZ QUARTZ HC-18U	707133	89536	707133	1	1	
Z 101	*	RESISTOR NETWORK RR LADDER	646828	89536	646828	1	1	
Z 301,303	*	RESISTOR NETWORK OUTPUT DIVIDER	655811	89536	655811	2	1	
Z 302	*	RESISTOR NETWORK DC INPUT DIVIDER	655852	89536	655852	1	1	
Z 304,402	*	RESISTOR NETWORK INPUT PROTECTION	715789	89536	715789	2	1	
Z 401	*	RESISTOR NETWORK OHMS	652867	89536	652867	1	1	
Z 702	*	RESISTOR NETWORK, REF AMP II	683110	89536	683110	1	1	

NOTE 1: R410 IS A FUSIBLE RESISTOR. USE EXACT REPLACEMENT TO INSURE SAFETY.

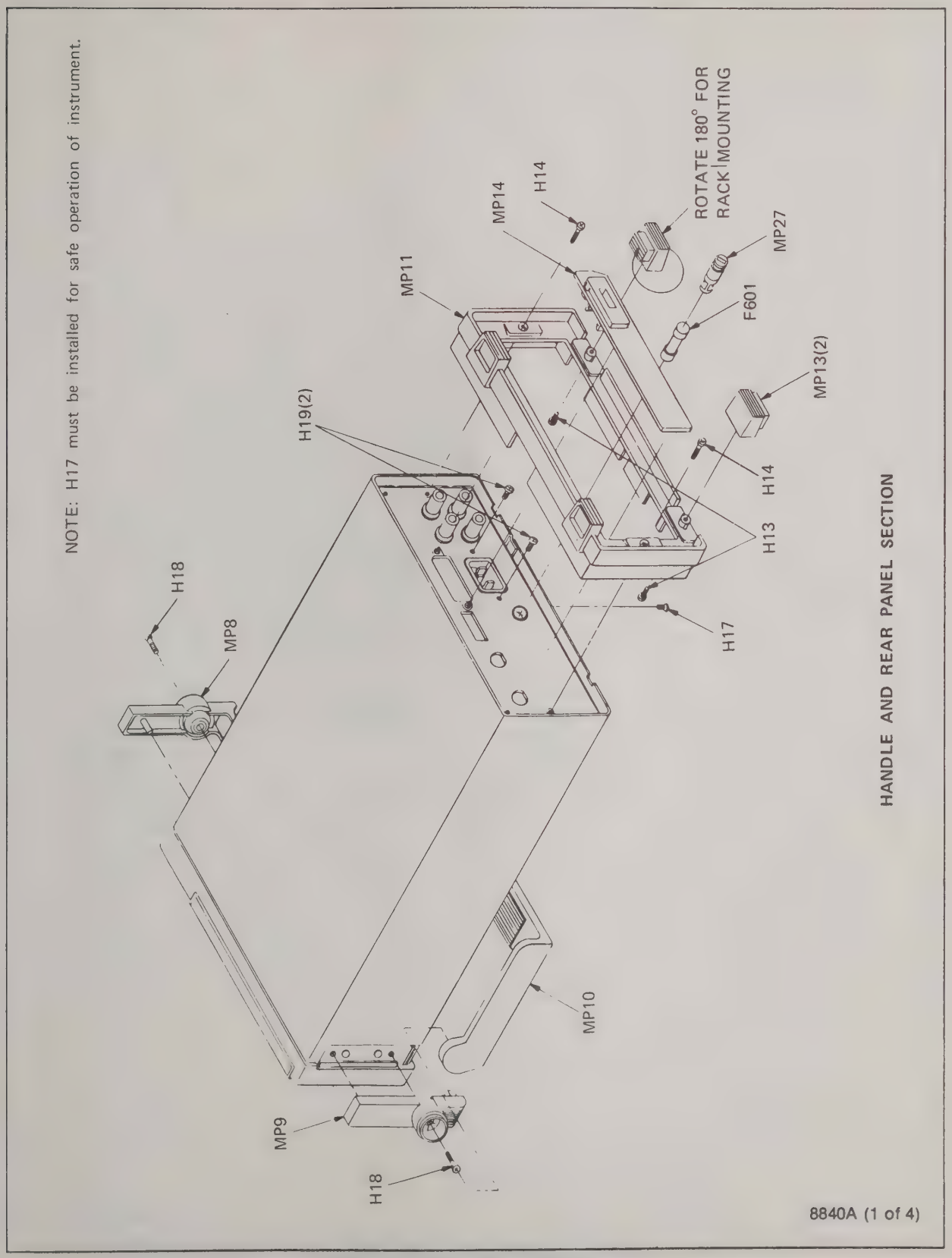
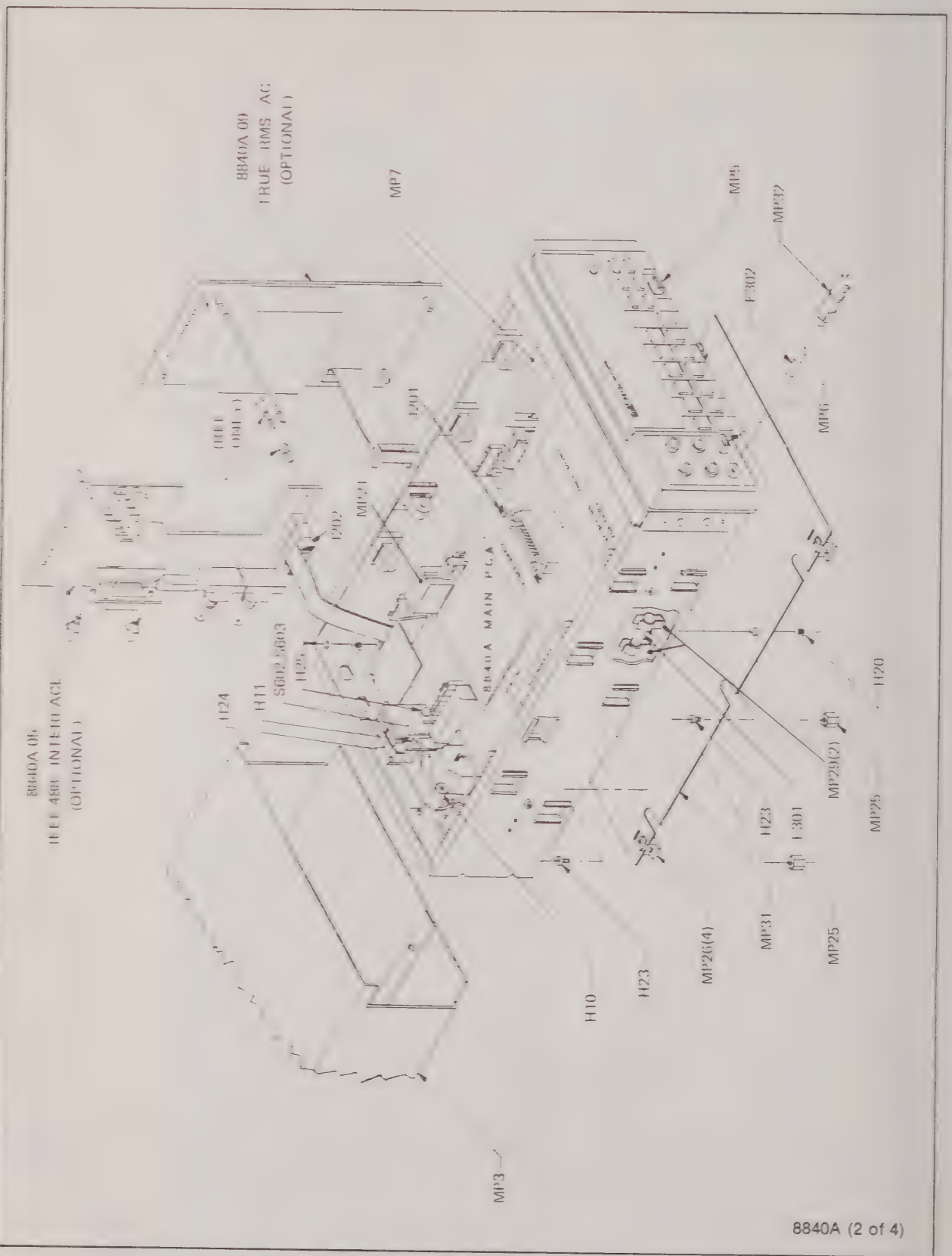


Figure 7-1. 8840A Digital Multimeter


8840A 08
TRUE RMS AC
(OPTIONAL)
MP7
MP5
MP32
F302
MP6
A1
A2
A3
A4
A5
A6
A7
A8
A9
A10
A11
A12
A13
A14
A15
A16
A17
A18
A19
A20
A21
A22
A23
A24
A25
A26
A27
A28
A29
A30
A31
A32
A33
A34
A35
A36
A37
A38
A39
A40

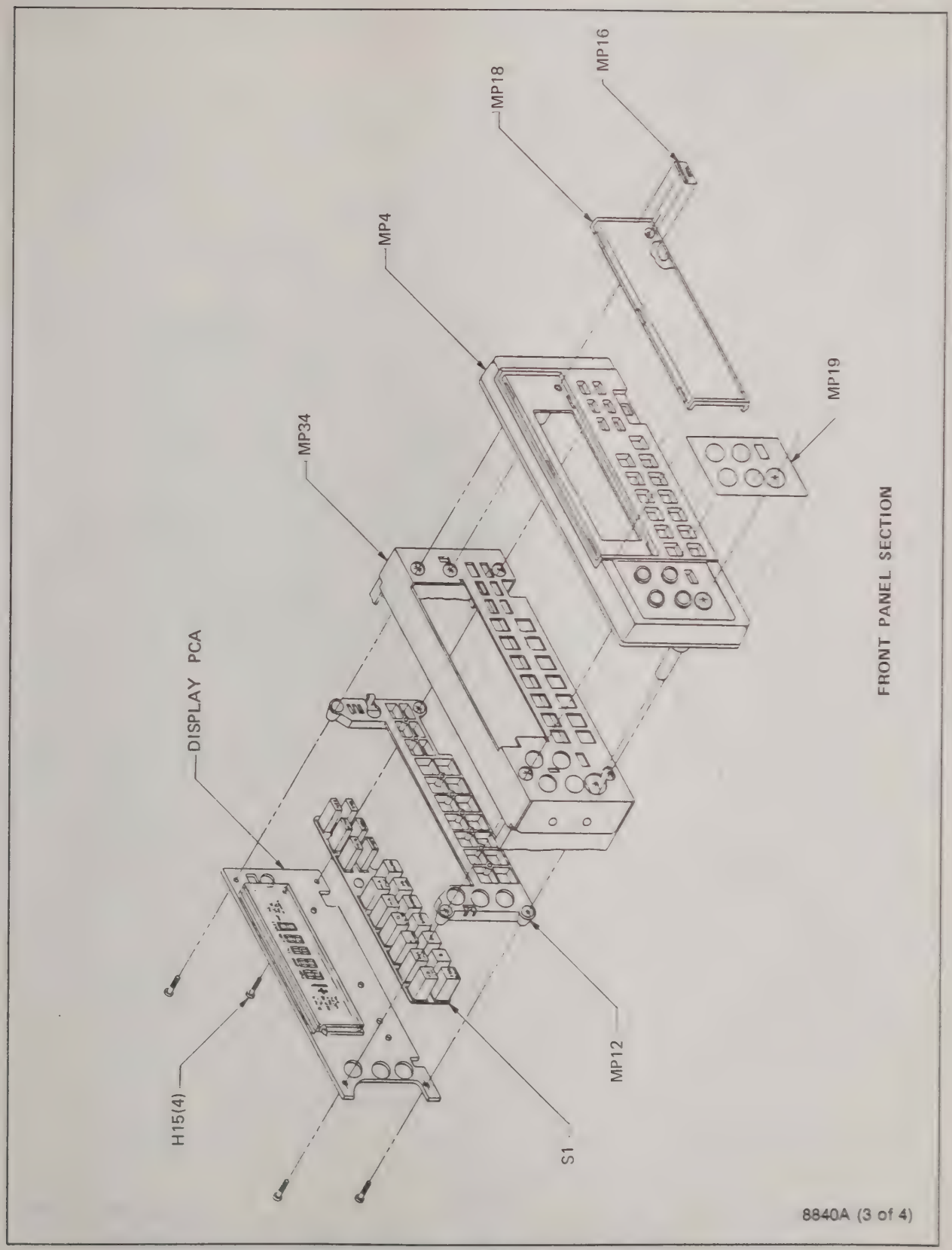


Figure 7-1. 8840A Digital Multimeter (cont)

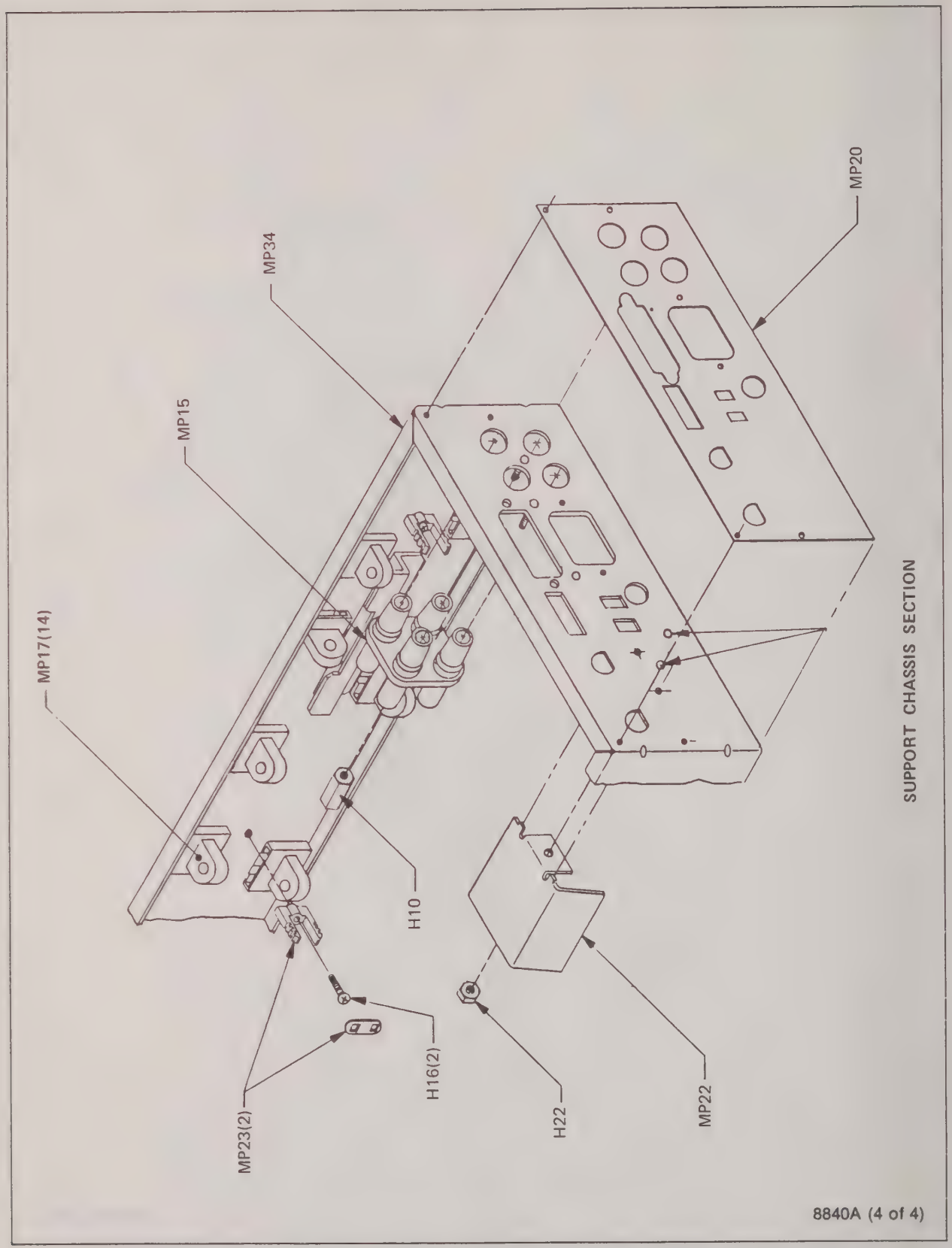


Figure 7-1. 8840A Digital Multimeter (cont)

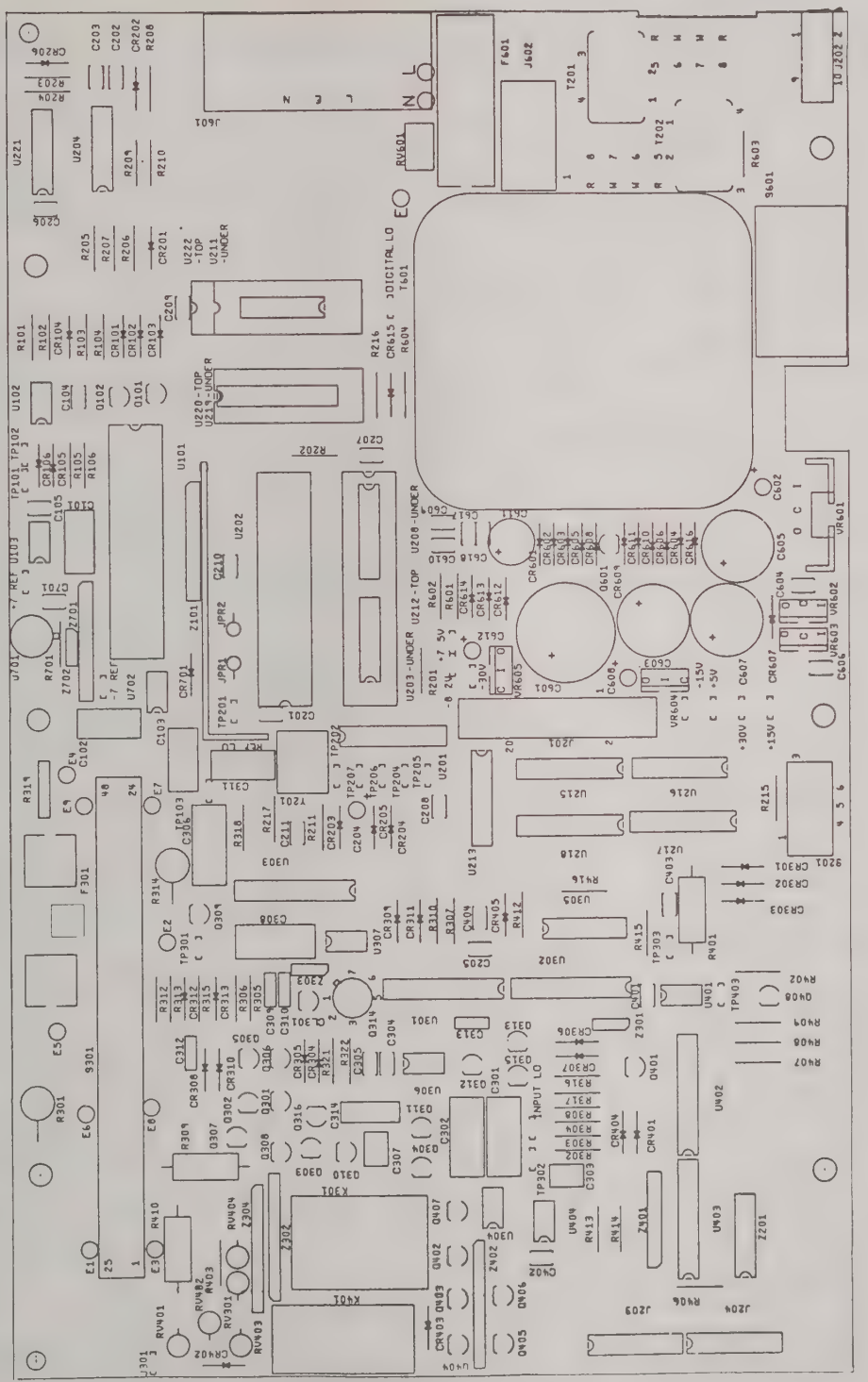


Figure 7-1. 8840A Digital Multimeter (cont)

Table 7-2. Federal Supply Codes for Manufacturers

00213
Nytronics Comp. Group Inc.
Subsidiary of Nytronics Inc.
Formerly Sage Electronics
Rochester, New York

00327
Welwyn International, Inc.
Westlake, Ohio

00656
Aerovox Corp.
New Bedford, Massachusetts

00686
Film Capacitors, Inc.
Passaic, New Jersey

00779
AMP Inc.
Harrisburg, Pennsylvania

01121
Allen-Bradley Co.
Milwaukee, Wisconsin

01281
TRW Electronic Comp.
Semiconductor Operations
Lawndale, California

01295
Texas Instruments, Inc.
Semiconductor Group
Dallas, Texas

01537
Motorola Communications &
Electronics Inc.
Franklin Park, Illinois

01686
RCL Electronics Inc.
Manchester, New Hampshire

01730
Replaced by 73586

01884
Use 56289
Sprague Electric Co.
Dearborn Electronic Div.
Lockwood, Florida

02114
Ferroxcube Corp.
Saugerties, New York

02131
General Instrument Corp.
Harris ASW Div.
Westwood, Maine

02395
Rason Mfg. Co.
Brooklyn, New York

02533
Snelgrove, C.R. Co., Ltd.
Don Mills, Ontario, Canada
M3B 1M2

02606
Fenwal Labs
Div. of Travenal Labs.
Morton Grove, Illinois

02660
Bunker Ramo Corp., Conn Div.
Formerly Amphenol-Borg
Electric Corp.
Broadview, Illinois

02799
Areo Capacitors, Inc.
Chatsworth, California

03508
General Electric Co.
Semiconductor Products
Syracuse, New York

03614
Replaced by 71400

03651
Replaced by 44655

03797
Eldema Div.
Genisco Technology Corp.
Compton, California

03877
Transistron Electronic Corp.
Wakefield, Massachusetts

03888
KDI Pyrofilm Corp.
Whippany, New Jersey

03911
Clairex Electronics Div.
Clairex Corp.
Mt. Vernon, New York

03980
Muirhead Inc.
Mountainside, New Jersey

04009
Arrow Hart Inc.
Hartford, Connecticut

04062
Replaced by 72136

04202
Replaced by 81312

04217
Essex International Inc.
Wire & Cable Div.
Anaheim, California

04221
Aemco, Div. of
Midtex Inc.
Mankato, Minnesota

04222
AVX Ceramics Div.
AVX Corp.
Myrtle Beach, Florida

04423
Telonic Industries
Laguna Beach, California

04645
Replaced by 75376

04713
Motorola Inc. Semiconductor
Products
Phoenix, Arizona

04946
Standard Wire & Cable
Los Angeles, California

05082
Replaced by 94988

05236
Jonathan Mfg. Co.
Fullerton, California

05245
Components Corp. now
Corcom, Inc.
Chicago, Illinois

05277
Westinghouse Electric Corp.
Semiconductor Div.
Youngwood, Pennsylvania

05278
Replaced by 43543

05279
Southwest Machine &
Plastic Co.
Glendora, California

05397
Union Carbide Corp.
Materials Systems Div.
New York, New York

05571
Use 56289
Sprague Electric Co.
Pacific Div.
Los Angeles, California

05574
Viking Industries
Chatsworth, California

05704
Replaced by 16258

05820
Wakefield Engineering Inc.
Wakefield, Massachusetts

06001
General Electric Co.
Electronic Capacitor &
Battery Products Dept.
Columbia, South Carolina

06136
Replaced by 63743

06383
Panduit Corp.
Tinley Park, Illinois

06473
Bunker Ramo Corp.
Amphenol SAMS Div.
Chatsworth, California

06555
Beede Electrical Instrument Co.
Penacook, New Hampshire

06739
Electron Corp.
Littleton, Colorado

06743
Clevite Corp.
Cleveland, Ohio

06751
Components, Inc. Semcor Div.
Phoenix, Arizona

06860
Gould Automotive Div.
City of Industry, California

06961
Vernitron Corp., Piezo
Electric Div.
Formerly Clevite Corp., Piezo
Electric Div.
Bedford, Ohio

06980
Eimac Div.
Varian Associates
San Carlos, California

07047
The Ross Milton Co.
South Hampton, Pennsylvania

07115
Replaced by 14674

07138
Westinghouse Electric Corp.,
Electronic Tube Div.
Horsehead, New York

07233
TRW Electronic Components
Cinch Graphic
City of Industry, California

07256
Silicon Transistor Corp.
Div. of BBF Group Inc.
Chelmsford, Massachusetts

07261
Aumet Corp.
Culver City, California

07263
Fairchild Semiconductor
Div. of Fairchild Camera
& Instrument Corp.
Mountain View, California

07344
Bircher Co., Inc.
Rochester, New York

07597
Burndy Corp.
Tape/Cable Div.
Rochester, New York

07792
Lerma Engineering Corp.
Northampton, Massachusetts

07910
Teledyne Semiconductor
Formerly Continental Device
Hawthorne, California

07933
Use 49956
Raytheon Co.
Semiconductor Div. HQ
Mountain View, California

08225
Industro Transistor Corp.
Long Island City, New York

Table 7-2. Federal Supply Codes for Manufacturers (cont)

08261
Spectra Strip Corp.
Garden Grove, California

08530
Reliance Mica Corp.
Brooklyn, New York

08806
General Electric Co.
Miniature Lamp Products Dept
Cleveland, Ohio

08863
Nylomatic Corp.
Norrisville, Pennsylvania

08988
Use 53085
Skottie Electronics Inc.
Archbald, Pennsylvania

09214
G.E. Co. Semi-Conductor
Products Dept.
Power Semi-Conductor
Products OPN Sec.
Auburn, New York

09353
C and K Components
Watertown, Massachusetts

09423
Scientific Components, Inc.
Santa Barbara, California

09922
Burndy Corp.
Norwalk, Connecticut

09969
Dale Electronics Inc.
Yankton, S. Dakota

10059
Barker Engineering Corp.
Formerly Amerace, Amerace
ESNA Corp.
Kenilworth, New Jersey

11236
CTS of Berne
Berne, Indiana

11237
CTS Keene Inc.
Paso Robles, California

11358
CBS Electronic Div.
Columbia Broadcasting System
Newburyport, Minnesota

11403
Best Products Co.
Chicago, Illinois

11503
Keystone Columbia Inc.
Warren, Michigan

11532
Teledyne Relays
Hawthorne, California

11711
General Instrument Corp.
Rectifier Division
Hicksville, New York

11726
Qualidyne Corp.
Santa Clara, California

12014
Chicago Rivet & Machine Co.
Bellwood, Illinois

12040
National Semiconductor Corp.
Danburry, Connecticut

12060
Diodes, Inc.
Chatsworth, California

12136
Philadelphia Handle Co.
Camden, New Jersey

12300
Potter-Brumfield Div.
AMF Canada LTD.
Guelph, Ontario, Canada

12323
Presin Co., Inc.
Shelton, Connecticut

12327
Freeway Corp. formerly
Freeway Washer & Stamping Co.
Cleveland, Ohio

12443
The Budd Co. Polychem Products
Plastic Products Div.
Bridgeport, Pennsylvania

12615
U.S. Terminals Inc.
Cincinnati, Ohio

12617
Hamlin Inc.
Lake Mills, Wisconsin

12697
Clarostat Mfg. Co.
Dover, New Hampshire

12749
James Electronics
Chicago, Illinois

12856
Micrometals
Sierra Madre, California

12954
Dickson Electronics Corp.
Scottsdale, Arizona

12969
Unitrode Corp.
Watertown, Massachusetts

13103
Thermalloy Co., Inc.
Dallas, Texas

13327
Solitron Devices Inc.
Tappan, New York

13511
Amphenol Cadre Div.
Bunker-Ramo Corp.
Los Gatos, California

13606
Use 56289
Sprague Electric Co.
Transistor Div.
Concord, New Hampshire

13839
Replaced by 23732

14099
Semtech Corp.
Newbury Park, California

14140
Edison Electronic Div.
Mc Gray-Edison Co.
Manchester, New Hampshire

14193
Cal-R-Inc. formerly
California Resistor, Corp.
Santa Monica, California

14298
American Components, Inc.
an Insilco Co.
Conshohocken, Pennsylvania

14655
Cornell-Dublier Electronics
Division of Federal Pacific
Electric Co. Govt. Control Dept.
Newark, New Jersey

14752
Electro Cube Inc.
San Gabriel, California

14869
Replaced by 96853

14936
General Instrument Corp.
Semi Conductor Products Group
Hicksville, New York

15636
Elec-Trol Inc.
Saugus, California

15801
Fenwal Electronics Inc.
Div. of Kidde Walter and Co., Inc.
Framingham, Massachusetts

15818
Teledyne Semiconductors,
formerly Amelco Semiconductor
Mountain View, California

15849
Litton Systems Inc. Useco Div.
formerly Useco Inc.
Van Nuys, California

15898
International Business
Machines Corp.
Essex Junction, Vermont

15909
Replaced by 14140

16258
Space-Lok Inc.
Burbank, California

16299
Corning Glass
Electronic Components Div.
Raleigh, North Carolina

16332
Replaced by 28478

16473
Cambridge Scientific Ind.
Div. of Chemed Corporation
Cambridge, Maryland

16742
Paramount Plastics
Fabricators, Inc.
Downey, California

16758
Delco Electronics
Div. of General Motors Corp.
Kokomo, Indiana

17001
Replaced by 71468

17069
Circuit Structures Lab.
Burbank, California

17338
High Pressure Eng. Co., Inc.
Oklahoma City, Oklahoma

17545
Atlantic Semiconductors, Inc.
Asbury Park, New Jersey

17856
Siliconix, Inc.
Santa Clara, California

17870
Replaced by 14140

18178
Vactec Inc.
Maryland Heights, Missouri

18324
Signetics Corp.
Sunnyvale, California

18612
Vishay Resistor Products Div.
Vishay Intertechnology Inc.
Malvern, Pennsylvania

18736
Voltronics Corp.
Hanover, New Jersey

18927
GTE Sylvania Inc.
Precision Material Group
Parts Division
Titusville, Pennsylvania

19451
Perine Machinery & Supply Co.
Seattle, Washington

19701
Electro-Midland Corp.
Mepco-Electra Inc.
Mineral Wells, Texas

20584
Enochs Mfg. Inc.
Indianapolis, Indiana

Table 7-2. Federal Supply Codes for Manufacturers (cont)

20891
Self-Organizing Systems, Inc.
Dallas, Texas

21604
Bucheye Stamping Co.
Columbus, Ohio

21845
Solitron Devices Inc.
Transistor Division
Riveria Beach, Florida

22767
ITT Semiconductors
Palo Alto, California

23050
Product Comp. Corp.
Mount Vernon, New York

23732
Tracor Inc.
Rockville, Maryland

23880
Stanford Applied Engrng.
Santa Clara, California

23936
Pamotor Div., Wm. J. Purdy Co.
Burlingame, California

24248
Replaced by 94222

24355
Analog Devices Inc.
Norwood, Massachusetts

24655
General Radio
Concord, Massachusetts

24759
Lenox-Fugle Electronics Inc.
South Plainfield, New Jersey

25088
Siemen Corp.
Isilen, New Jersey

25403
Amperex Electronic Corp.
Semiconductor &
Micro-Circuits Div.
Slatersville, Rhode Island

27014
National Semiconductor Corp.
Santa Clara, California

27264
Molex Products
Downers Grove, Illinois

28213
Minnesota Mining & Mfg. Co.
Consumer Products Div.
St. Paul, Minnesota

28425
Serv-/-Link formerly
Bohannan Industries
Fort Worth, Texas

28478
Deltrol Controls Div.
Deltrol Corporation
Milwaukee, Wisconsin

28480
Hewlett Packard Co.
Corporate HQ
Palo Alto, California

28520
Heyman Mfg. Co.
Kenilworth, New Jersey

29083
Monsanto, Co., Inc.
Santa Clara, California

29604
Stackpole Components Co.
Raleigh, North Carolina

30148
AB Enterprise Inc.
Ahoskie, North Carolina

30323
Illinois Tool Works, Inc.
Chicago, Illinois

31091
Optimax Inc.
Colmar, Pennsylvania

32539
Mura Corp.
Great Neck, New York

32767
Griffith Plastic Corp.
Burlingame, California

32879
Advanced Mechanical
Components
Northridge, California

32897
Erie Technological Products, Inc.
Frequency Control Div.
Carlisle, Pennsylvania

32997
Bourns Inc.
Trimpot Products Division
Riverside, California

33173
General Electric Co.
Products Dept.
Owensboro, Kentucky

34333
Silicon General
Westminister, California

34335
Advanced Micro Devices
Sunnyvale, California

34802
Electromotive Inc.
Kenilworth, New Jersey

37942
P.R. Mallory & Co., Inc.
Indianapolis, Indiana

42498
National Radio
Melrose, Massachusetts

43543
Nytronics Inc.
Transformer Co. Div.
Geneva, New York

44655
Ohmite Mfg. Co.
Skokie, Illinois

49671
RCA Corp.
New York, New York

49956
Raytheon Company
Lexington, Massachusetts

50088
Mostek Corp.
Carrollton, Texas

50579
Litronix Inc.
Cupertino, California

51605
Scientific Components Inc.
Linden, New Jersey

53021
Sangamo Electric Co.
Springfield, Illinois

54294
Cutler-Hammer Inc. formerly
Shallcross, A Cutter-Hammer Co.
Selma, North Carolina

55026
Simpson Electric Co.
Div. of Am. Gage and Mach. Co.
Elgin, Illinois

56289
Sprague Electric Co.
North Adams, Massachusetts

58474
Superior Electric Co.
Bristol, Connecticut

60399
Torin Corp. formerly
Torrington Mfg. Co.
Torrington, Connecticut

63743
Ward Leonard Electric Co., Inc.
Mount Vernon, New York

64834
West Mfg. Co.
San Francisco, California

65092
Weston Instruments Inc.
Newark, New Jersey

66150
Winslow Tele-Tronics Inc.
Eaton Town, New Jersey

70485
Atlantic India Rubber Works
Chicago, Illinois

70563
Amperite Company
Union City, New Jersey

70903
Belden Corp.
Geneva, Illinois

71002
Birnback Radio Co., Inc.
Freeport, New York

71400
Bussmann Mfg.
Div. of McGraw-Edison Co.
Saint Louis, Missouri

71450
CTS Corp.
Elkhart, Indiana

71468
ITT Cannon Electric Inc.
Santa Ana, California

71482
Clare, C.P. & Co.
Chicago, Illinois

71590
Centrelab Electronics
Div. of Globe Union Inc.
Milwaukee, Wisconsin

71707
Coto Coil Co., Inc.
Providence, Rhode Island

71744
Chicago Miniature Lamp Works
Chicago, Illinois

71785
TRW Electronics Components
Cinch Connector Operations Div.
Elk Grove Village
Chicago, Illinois

72005
Wilber B. Driver Co.
Newark, New Jersey

72092
Replaced by 06980

72136
Electro Motive Mfg. Co.
Williamantic, Connecticut

72259
Nytronics Inc.
Pelham Manor, New Jersey

72619
Dialight Div.
Amperex Electronic Corp.
Brooklyn, New York

72653
G.C. Electronics
Div. of Hydrometals, Inc.
Brooklyn, New York

72665
Replaced by 90303

72794
Dzus Fastener Co., Inc.
West Islip, New York

72928
Gulton Ind. Inc.
Gudeman Div.
Chicago, Illinois

Table 7-2. Federal Supply Codes for Manufacturers (cont)

72982
Erie Tech. Products Inc.
Erie, Pennsylvania

73138
Bechman Instrument Inc.
Helipot Division
Fullerton, California

73293
Hughes Aircraft Co.
Electron Dynamics Div.
Torrance, California

73445
Amperex Electronic Corp.
Hicksville, New York

73559
Carling Electric Inc.
West Hartford, Connecticut

73586
Circle F Industries
Trenton, New Jersey

73734
Federal Screw Products, Inc.
Chicago, Illinois

73743
Fischer Special Mfg. Co.
Cincinnati, Ohio

73899
JFD Electronics Co.
Components Corp.
Brooklyn, New York

73949
Guardian Electric Mfg. Co.
Chicago, Illinois

74199
Quan Nichols Co.
Chicago, Illinois

74217
Radio Switch Corp.
Marlboro, New Jersey

74276
Signalite Div.
General Instrument Corp.
Neptune, New Jersey

74306
Piezo Crystal Co.
Carlisle, Pennsylvania

74542
Hoyt Elect. Instr. Works
Penacook, New Hampshire

74970
Johnson E.F., Co.
Waseca, Minnesota

75042
TRW Electronics Components
IRC Fixed Resistors
Philadelphia, Pennsylvania

75376
Kurz-Kasch Inc.
Dayton, Ohio

75378
CTS Knights Inc.
Sandwich, Illinois

75382
Kulka Electric Corp.
Mount Vernon, New York

75915
Littlefuse Inc.
Des Plaines, Illinois

76854
Oak Industries Inc.
Switch Div.
Crystal Lake, Illinois

77342
AMF Inc.
Potter & Brumfield Div.
Princeton, Indiana

77638
General Instrument Corp.
Rectifier Division
Brooklyn, New York

77969
Rubbercraft Corp. of CA. LTD.
Torrance, California

78189
Shakeproof
Div. of Illinois Tool Works Inc.
Elgin, Illinois

78277
Sigma Instruments, Inc.
South Braintree, Massachusetts

78488
Stackpole Carbon Co.
Saint Marys, Pennsylvania

78553
Eaton Corp. Engineered
Fastener Div.
Tinnerman Plant
Cleveland, Ohio

79136
Waldes Kohinoor Inc.
Long Island City, New York

79497
Western Rubber Company
Goshen, Indiana

79963
Zierick Mfg. Corp.
Mt. Kisko, New York

80031
Electro-Midland Corp.
Mepco Div.
A North American Phillips Co.
Norristown, New Jersey

80145
LFE Corp., Process Control Div.
formerly API Instrument Co.
Chesterland, Ohio

80183
Use 56289
Sprague Products
North Adams, Massachusetts

80294
Bourns Inc., Instrument Div.
Riverside, California

80583
Hammarlund Mfg. Co., Inc.
Red Bank, New Jersey

80640
Arnold Stevens, Inc.
South Boston, Massachusetts

81073
Grayhill, Inc.
La Grange, Illinois

81312
Winchester Electronics
Div. of Litton Industries Inc.
Oakville, Connecticut

81483
Therm-O-Disc Inc.
Mansfield, Ohio

81483
International Rectifier Corp.
Los Angeles, California

81590
Korry Mfg. Co.
Seattle, Washington

81741
Chicago Lock Co.
Chicago, Illinois

82305
Palmer Electronics Corp.
South Gate, California

82389
Switchcraft Inc.
Chicago, Illinois

82415
North American Phillips
Controls Corp.
Frederick, Maryland

82872
Roanwell Corp.
New York, New York

82877
Rotron Inc.
Woodstock, New York

82879
ITT Royal Electric Div.
Pawtucket, Rhode Island

83003
Varo Inc.
Garland, Texas

83058
The Carr Co., United Can Div.
of TRW
Cambridge, Massachusetts

83298
Bendix Corp.
Electric Power Div.
Eatontown, New Jersey

83330
Herman H. Smith, Inc.
Brooklyn, New York

83478
Rubbercraft Corp.
of America, Inc.
West Haven, Connecticut

83594
Burroughs Corp.
Electronic Components Div.
Plainfield, New Jersey

83740
Union Carbide Corp.
Battery Products Div.
formerly Consumer Products Div.
New York, New York

84171
Arco Electronics
Great Neck, New York

84411
TRW Electronic Components
TRW Capacitors
Ogallala, Nebraska

84613
Fuse Indicator Corp.
Rockville, Maryland

84682
Essex International Inc.
Industrial Wire Div.
Peabody, Massachusetts

86577
Precision Metal Products
of Malden Inc.
Stoneham, Massachusetts

86684
Radio Corp. of America
Electronic Components Div.
Harrison, New Jersey

86928
Seastrom Mfg. Co., Inc.
Glendale, California

87034
Illuminated Products Inc.
Subsidiary of Oak Industries Inc.
Anahiem, California

88219
Gould Inc.
Industrial Div.
Trenton, New Jersey

88245
Litton Systems Inc.
Useco Div.
Van Nuys, California

88419
Cornell-Dubilier Electronic Div.
Federal Pacific Co.
Fuquay-Varian, North Carolina

88486
Plastic Wire & Cable
Jewitt City, Connecticut

88690
Replaced by 04217

89536
John Fluke Mfg. Co., Inc.
Seattle, Washington

89730
G.E. Co., Newark Lamp Works
Newark, New Jersey

Table 7-2. Federal Supply Codes for Manufacturers (cont)

90201
Mallory Capacitor Co.
Div. of P.R. Mallory Co., Inc.
Indianapolis, Indiana

90211
Use 56365
Square D Co.
Chicago, Illinois

90215
Best Stamp & Mfg. Co.
Kansas City, Missouri

90303
Mallory Battery Co.
Div. of Mallory Co., Inc.
Tarrytown, New York

91094
Essex International Inc.
Suglex/IWP Div.
Newmarket, New Hampshire

91293
Johanson Mfg. Co.
Boonton, New Jersey

91407
Replaced by 58474

91502
Associated Machine
Santa Clara, California

91506
Augat Inc.
Attleboro, Massachusetts

91637
Dale Electronics Inc.
Columbus, Nebraska

91662
Elco Corp.
Willow Grove, Pennsylvania

91737
Use 71468
Gremar Mfg. Co., Inc.
ITT Cannon/Gremar
Santa Ana, California

91802
Industrial Devices, Inc.
Edgewater, New Jersey

91833
Keystone Electronics Corp.
New York, New York

91836
King's Electronics Co., Inc.
Tuckahoe, New York

91929
Honeywell Inc.
Micro Switch Div.
Freeport, Illinois

91934
Miller Electric Co., Inc.
Div. of Aunet
Woonsocket, Rhode Island

92194
Alpha Wire Corp.
Elizabeth, New Jersey

93332
Sylvania Electric Products
Semiconductor Products Div.
Woburn, Massachusetts

94145
Replaced by 49956

94154
Use 94988
Wagner Electric Corp.
Tung-Sol Div.
Newark, New Jersey

94222
Southco Inc. formerly
South Chester Corp.
Lester, Pennsylvania

95146
Alco Electronic Products Inc.
Lawrence, Massachusetts

95263
Leecraft Mfg. Co.
Long Island City, New York

95264
Replaced by 98278

95275
Vitramon Inc.
Bridgeport, Connecticut

95303
RCA Corp.
Receiving Tube Div.
Cincinnati, Ohio

95348
Gordo's Corp.
Bloomfield, New Jersey

95354
Methode Mfg. Corp.
Rolling Meadows, Illinois

95712
Bendix Corp.
Electrical Components Div.
Microwave Devices Plant
Franklin, Indiana

95987
Weckesser Co. Inc.
Chicago, Illinois

96733
San Fernando Electric Mfg. Co.
San Fernando, California

96853
Gulton Industries Inc.
Measurement and Controls Div.
formerly Rustrak Instruments Co.
Manchester, New Hampshire

96881
Thomson Industries, Inc.
Manhasset, New York

97540
Master Mobile Mounts, Div. of
Whitehall Electronics Corp.
Ft. Meyers, Florida

97913
Industrial Electronic
Hardware Corp.
New York, New York

97945
Penwalt Corp.
SS White Industrial Products Div.
Piscataway, New Jersey

97966
Replaced by 11358

98094
Replaced by 49956

98159
Rubber-Teck, Inc.
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99392
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99779
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TLX: 36206

Australia, Brisbane
Elmeasco Instruments Pty Ltd.
Tel: (07) 229-3161

Austria, Vienna
Walter Rekirsch Electronische Gerate GmbH & Co.
Tel: (0222) 235555
TLX: 134759

Belgium, Brussels
Fluke (Belgium) SA/NA
Tel: (02) 2164090
TLX: 26312

Brazil, Sao Paulo
Fluke Brasil-Industria E Comercio Ltda.
Tel: (011) 421-3603
TLX: 01135589 FLKE BR

Canada, Calgary, AB
Allan Crawford Associates Ltd.
Tel: (403) 230-1341

Canada, Burnaby, BC
Allan Crawford Associates Ltd.
Tel: (604) 294-1326

Canada, Mississauga, ON
Allan Crawford Associates Ltd.
Tel: (416) 678-1500

Canada, St. Laurent, PQ
Allan Crawford Associates Ltd.
Tel: (514) 731-8564

Chile, Santiago
Intronica Chile Ltda.
Tel: 44940
TLX: 240301

China, Beijing
Beijing Radio Research Institute
Tel: 445612

Colombia, Bogota
Sistemas E Instrumentacion, Ltda.
Tel: 232-45-32
TLX: 45787 COASN CO

Denmark, Ballerup
Tage Olsen A/S
Tel: (02) 658111
TLX: 35293 TOAS SK

Ecuador, Quito
Edificio "Jerico"
Tel: 529684, 526759
TLX: 2865 Protec Ed

Egypt, Cairo
Electronic Engineering Liaison Office
Tel: 691588
TLX: (927) 92502

England, Watford, Herts
Fluke (Great Britain) LTD
Tel. 44-923-40511
TLX: 934583

Finland, Kauniainen
Oy Findip AB
Tel: (0) 5052255
TLX: 123129

France, BUC
M.B. Electronique S.A.
Tel: (01) 9568131
TLX: 695414

Greece, Athens
Hellenic Scientific Representations
Tel: (01) 711140
TLX: 219330

Hong Kong, Hong Kong
Schmidt & Co. (H.K.) Ltd.
Tel: 5-455644
TLX: 74766 SCHMC HX

India, Bombay
Hinditron Services Pvt. Ltd.
Tel: 811316, 815344
TLX: 953-112326 HSPL IN

India, Bangalore
Hinditron Services Pvt. Ltd.
Tel: 33139
TLX: 0845741

India, New Delhi
Hinditron Services Pvt. Ltd.
Tel: 619118
TLX: 031 4890 SRMP IN

Indonesia, Jakarta Selatan
P.T. Dwi Tunggal Jaya Sakti
Tel: 716374
TLX: 47308 DIJS IA

Israel, Ramat Hasharon
R.D.T. Electronics Engineering Ltd.
Tel: (03) 483216
TLX: 32143

Italy, Milan
Sistrel S.p.A.
Tel: (02) 6181893
TLX: 334643

Italy, Rome
Sistrel S.p.A.
Tel: (06) 5915551
TLX: 68356

Japan, Tokyo
John Fluke Mfg. Co., Inc.
Japan Branch
Tel: (03) 434-0181
TLX: (781) 2424331 (FLUKJPJ)

Korea, Seoul
Electro-Science Korea Co.
Tel: 261-7702, 260-1908
TLX: K25381

Malaysia, Petaling Jaya
Mecomb Malaysia SDN BHD
Tel: 573455
TLX: MA37605

Mexico, Mexico D.F.
Electronica y Tecnologia Avanzada S.A. de C.V. (ETA)
Tel: 393 09 02 or 393 57 62
TLX: 0172697 BLOSME

Netherlands, Maarssen
Fluke (Nederland) B.V.
Tel: (030) 436514
TLX: 47128

Netherlands, Tilburg
Fluke (Holland) B.V.
Tel: (013) 673973
TLX: 52237

New Zealand, Auckland
McLean Information Technology, Ltd.
Tel: 501-801, 501-219, 587-037
TLX: NZ21570 THERMAL

Norway, Oslo
Morgenstierne & Co A/S
Tel: (02) 356110
TLX: 71719

Pakistan, Karachi
Pak International Operations
Tel: 221127, 239052
TLX: 24494 PIO PK

Peru, Lima
Importaciones Y Representaciones Electronicas S.A.
Tel: 288650
TLX: 37425663

Philippines, Metro Manila
Spark Radio & Electronics Corp.
Tel: 78-78-16
TLX: 27901 RLA PH

Portugal, Lisboa
Decada-Equipamentos de Electronica, Lda.
Tel: (19) 574984
TLX: 18469

Republic of Singapore, Singapore
Rank O'Connor's (PTE) Limited
Tel: 637944, 239052
TLX: OCONSIN RS21023

Republic of South Africa, Bramley
Fluke S.A. (Pty) Ltd.
Tel: (011) 786-3170
TLX: 424328

Spain, Alcorcon (Madrid)
Hispano Electronics S.A.
Tel: (01) 6194108
TLX: 22404/42634

Sweden, Vallingby
Teleinstrument AB
Tel: (08) 380370
TLX: 15770

Switzerland, Zurich
Traco Electronic AG
Tel: (01) 2010711
TLX: 54318

Taiwan, Taipei
Schmidt Scientific Far East Ltd.
Tel: 5414600
TLX: 11111 Schmidt

Thailand, Bangkok
Measuretronix Ltd.
Tel: 3143369, 3143430
TLX: 81143 DEJOBKK TH

Turkey, Istanbul
Erkman Elektronik Aletler
Tel: (01) 5461
TLX: 23353

Uruguay, Montevideo
Coasin Uruguaya S.R.L.
Tel: 29-31-952
TLX: UY 6571 OROCUER

Venezuela, Caracas
Coasin, C.A.
Tel: 38-78-42, 38-78-86
TLX: 21027 EMVEN VE

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Fluke (Deutschland) GmbH
Tel: (089) 96050
TLX: 0522472

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Litho in U.S.A. 4/84

Section 8
Options and Accessories

8-1. INTRODUCTION

A number of options and accessories are available which can enhance the 8840A's capabilities and increase operator safety. The accessories are summarized in Table 8-1 and described in the following paragraphs. The options are summarized in Table 8-2 and described in the following subsections.

Table 8-1. Accessories

MODEL	DESCRIPTION
Y8021	IEEE-488 Interface Cable (1m)
Y8022	IEEE-488 Interface Cable (2m)
Y8023	IEEE-488 Interface Cable (4m)
Y8834	Single Rack-Mount Kit
Y8835	Dual Rack-Mount Kit
TL70	Replacement Test Leads
Y8134	Deluxe Test Lead Kit
Y8140	Slim-Flex Test Leads
80T-150C	Temperature Probe (Celsius)
80T-150F	Temperature Probe (Fahrenheit)
85RF	RF Probe (100 kHz to 500 MHz)
83RF	RF Probe (100 kHz to 100 MHz)
80J-10	Current Shunt
Y8100	Current Probe (200A ac/dc)
Y8101	Current Probe (150A ac)
Y80I-600	Current Probe (600A ac)
80K-6	High Voltage Probe (6000V)
80K-40	High Voltage Probe (40,000V)

8-2. ACCESSORIES

Accessories include a variety of rack-mounting kits, cables, test leads, and probes. The accessories include installation and/or operating instructions.

Table 8-2. Options

NUMBER	OPTION
-05	IEEE-488 Interface
-09	True RMS AC

8-3. Rack-Mount Kits (Y8834, Y8835 and Y8836)

The rack-mount kits allow the 8840A to be mounted in standard 19-inch rack panels. The Y8834 kit allows the 8840A to be mounted either on the left or the right. The Y8835 kit allows two 8840As to be mounted side-by-side. The Y8836 kit allows the 8840A to be mounted in the center of the rack. Installation instructions are given in Section 2, and are also included with each kit.

8-4. Shielded IEEE-488 Interface Cables (Y8021, Y8022, and Y8023)

Shielded IEEE-488 cables are available in three lengths (see Table 8-1). The cables attach the 8840A to any other IEEE-488 device. Each cable has double 24-pin connectors at both ends to allow stacking. Metric threaded mounting screws are provided with each connector.

8-5. Replacement Test Leads (TL70)

The TL70 replacement test leads feature safety-designed input connectors.

8-6. Deluxe Test Lead Kits (Y8134)

Each deluxe test lead kit includes two test-tip probes, two alligator clips, two large spade lug tips, and one spring-loaded hook tip and probe.

8-7. Slim-Flex Test Leads (Y8140)

The Y8140 has adjustable, flexible, and insulated leads, and can fit into small places. The sharp steel needle points will pierce varnish and thin insulation.

8-8. Temperature Probes (80T-150C and 80T-150F)

The 80T-150C and 80T-150F convert any DMM into a thermometer. The 80T-150C responds in degrees Celsius; the 80T-150F responds in degrees Fahrenheit.

8-9. RF Probes (85RF and 83RF)

The RF probes (85RF and 83RF) use the DMM dc volts function to measure radio frequency (RF) ac signals. The 83RF has a frequency range of 100 kHz to 100 MHz; the 85RF has a frequency range of 100 kHz to 500 MHz. The probes are calibrated so that the dc output is equivalent to the rms value of a sine wave input over a range of 0.25V to 30V rms.

For best accuracy, the probes should be used with DMMs having 10 MΩ input impedance. This condition is satisfied by the 8840A in the 200V and 1000V ranges. The probes can also be used with the 8840A in the 200 mV, 2V, and 20V ranges if a 10 MΩ resistor is connected in parallel across the 8840A input terminals.

8-10. Current Shunt (80J-10)

The 80J-10 current shunt extends ac or dc current measurement up to 10A continuous, or to 20A for one minute without overheating.

8-11. Current Probes (Y8100, Y8101, and Y80I-600)

The current probes extend the ac and dc current measurement range. The Y8100 current probe uses the Hall effect to measure dc or ac current up to 200A (in two ranges) without electrical contact. The Y8101 is a low-cost, compact current probe which uses a transformer to measure ac current from 2A to 150A. The Y80I-600 uses a transformer to measure ac current from 1A to 600A, and features a large jaw opening for industrial use. The Y8101 and Y80I-600 measure ac current only.

8-12. High Voltage Probes (80K-6 and 80K-40)

The high voltage probes extend the dc and ac voltage measurement range while minimizing shock hazard. The 80K-6 has a range of 0 to 6000V dc or peak ac, with frequency response to 1 kHz; the 80K-40 has a range of 0 to 40,000V dc or peak ac, with frequency response to 60 Hz. As the probes use 1000:1 dividers, the probes have a high input impedance and cause minimal circuit loading. The probes are impedance matched for both ac and dc measurements. A plastic body protects the operator from the voltage being measured.

For best accuracy, the probes should be used with DMMs having 10 MΩ input impedance. This condition is satisfied by the 8840A in the 200V dc and 1000V dc ranges. The probes can also be used with the 8840A in the 200 mV dc, 2V dc, and 20V dc ranges if a 10 MΩ resistor is connected in parallel across the input terminals.

8-13. Troubleshooting Kit (8840A-9000)

The 8840A-9000 Troubleshooting Kit contains an entire fault isolation procedure on mini cassette tapes for the digital circuitry of the 8840A. The troubleshooting kit must be used in conjunction with a 9010A or 9005A Micro-System Troubleshooter and a 9000A-8048 Interface Pod. The troubleshooting kit allows a service technician to quickly isolate a digital fault on the Main PCA, Display PCA, and IEEE-488 PCA of the 8840A.

The 8840A-9000 is a powerful diagnostic tool for the service technician. The troubleshooting kit makes the task of troubleshooting the 8840A easier and faster than conventional servicing techniques using an oscilloscope and schematics. Some of the advantages of using the troubleshooting kit are:

- Guided fault isolation is easy to learn, giving the technician immediate response for greater repair throughput.
- Fault isolation of the 8840A's digital circuitry can be done rapidly.
- The technician can troubleshoot the circuitry without studying it.
- Ready-to-use programs eliminate extensive, time-consuming software development.
- Printed test results are available on an optional printer.

When the troubleshooter is connected to the microprocessor socket, it takes over digital activity normally performed by the Z8 microprocessor. By eliminating the microprocessor, the troubleshooter can interact directly with the circuitry of the 8840A. The troubleshooter takes control of the microprocessor bus to exercise and test ROM, RAM, I/O, and all other circuits that are bus related. Additional troubleshooting access is provided by a smart troubleshooting probe, which reads data from nodes located on or off the bus.

The troubleshooter's capabilities are more powerful when they are incorporated into stored mini cassette programs. These programs are designed to completely exercise the 8840A. The programs use prompt messages to guide the technician in performing a series of tests to exercise all digital circuitry from the microprocessor socket outward. These tests are executed in a logical order; the begin at the microprocessor socket and proceed outward, going completely through the digital circuitry of the 8840A. The results of each test are compared to the expected results stored in the program on the mini cassette tapes and reported to the operator via the troubleshooter's display.

Option -05
IEEE-488 Interface

805-1. INTRODUCTION

The IEEE-488 Interface turns the 8840A into a fully programmable instrument for use with the IEEE Standard 488-1978 interface bus (IEEE-488 bus). With the IEEE-488 Interface, the 8840A can become part of an automated instrumentation system. The 8840A can be under complete, interactive control from a remote bus controller, or it can be set to the talk-only mode, connected to a data logger or printer, and dedicated to a single task.

805-2. CAPABILITIES

The IEEE-488 Interface provides remote control of all front panel controls except for the POWER, CAL ENABLE, and FRONT/REAR switches. Other features include:

- A simple and predictable command set
- Fast measurement throughput
- Full talk/listen capability, including talk-only operation
- Full serial poll capability, with bit-maskable SRQ
- Full remote/local capability, including local lockout
- External Trigger and Sample Complete connectors
- Remote calibration
- Programmable trigger sources, including two bus triggers
- Informative output suffix (suppressible)
- Selectable output terminators

The 8840A supports the following interface function subsets: SH1, AH1, T5, L4, SR1, RL1, DC1, DT1, E1, PP0, and C0.

805-3. EXTERNAL CONTROLS

When the IEEE-488 Interface is installed, the rear panel contains EXT TRIG (External Trigger) and SAMPLE COMPLETE connectors. These controls can be used even when the 8840A is disconnected from the IEEE-488 bus. Refer to Section 2 for details.

805-4. INSTALLATION

The IEEE-488 Interface is contained on a single, easy-to-install printed circuit assembly (PCA). To install the option, proceed as follows:

WARNING

TO AVOID ELECTRIC SHOCK, DISCONNECT THE POWER CORD AND ANY INPUT LEADS BEFORE REMOVING THE INSTRUMENT CASE.

1. Remove the grounding screw from the bottom of the case and remove the two rear panel mounting screws (Figure 805-1A).
2. Holding the front panel, slide the case and rear bezel off of the chassis (Figure 805-1B). Note: At this point, the rear bezel is not secured to the case.

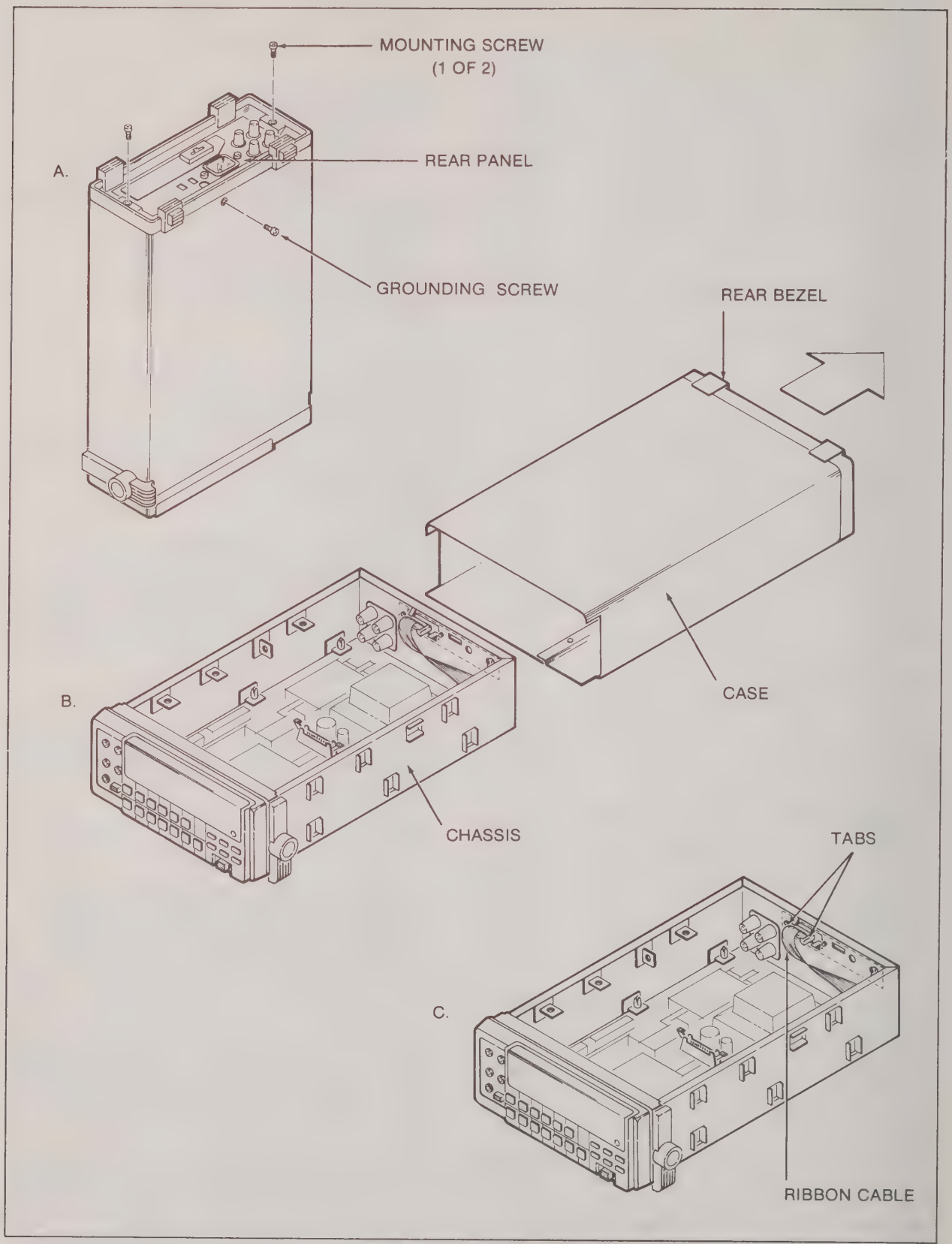


Figure 805-1. Installing Option -05

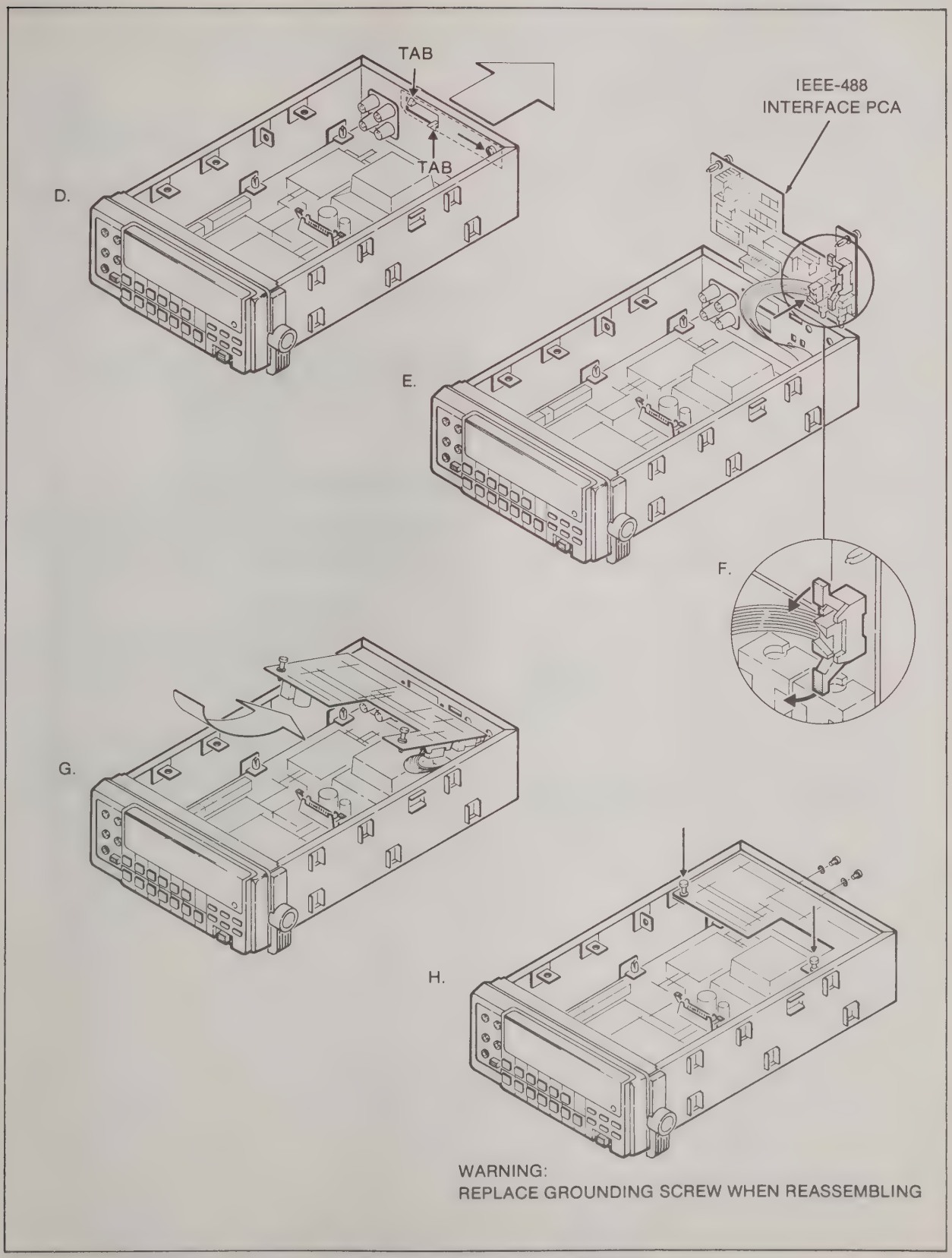


Figure 805-1. Installing Option -05 (cont)

3. Disconnect the ribbon cable from the plastic rear panel insert by pulling the tabs on either side of the ribbon cable connector outward. Pull the ribbon cable directly toward the front panel (Figure 805-1C).

4. Remove the rear panel insert by releasing the two snap tabs inside the instrument (Figure 805-1D).

NOTE

The connection on the rear panel insert is used for factory calibration only. The connector is electrically isolated from all measurieng circuitry.

5. Connect the the ribbon cable from the Main PCA to the connector on the IEEE-488 Interface PCA (Figure 805-1E).

6. Latch the ribbon cable in place as shown in Figure 805-1F.

7. Make sure the heads of the plastic latches are in the extended postion.

8. With the component side down, guide the BNC and IEEE-488 connectors (located on the rear of the IEEE-488 Interface PCA) into the rear panel, and seat the IEEE-488 Interface PCA on the mounting supports on the chassis (Figure 805-1G).

9. Fasten the IEEE-488 Interface PCA to the chassis by pressing the two plastic latches into the mounting supports. (See Figure 805-1H.)

10. Secure the IEEE-488 connector to the rear panel with the two screws and washers supplied.

11. Replace the cover and rear bezel on the chassis and attach the two rear panel mounting screws.

12. Attach the grounding screw to the bottom of the case.

WARNING

TO AVOID ELECTRIC SHOCK, ENSURE THE GROUNDING SCREW IS FIRMLY ATTACHED TO THE CASE BOTTOM.

805-5. PROGRAMMING INSTRUCTIONS

Programming instructions are presented in Section 3. That section also explains how to set up the 8840A on the IEEE-488 bus.

805-6. MAINTENANCE

All service information regarding option -05 is contained in Section 6. The theory of operation is contained in Section 5.

805-7. LIST OF REPLACEABLE PARTS

A list of replaceable parts for the IEEE-488 Interface printed circuit assembly (PCA) is given in Table 805-1. Refer to Section 7 for ordering information.

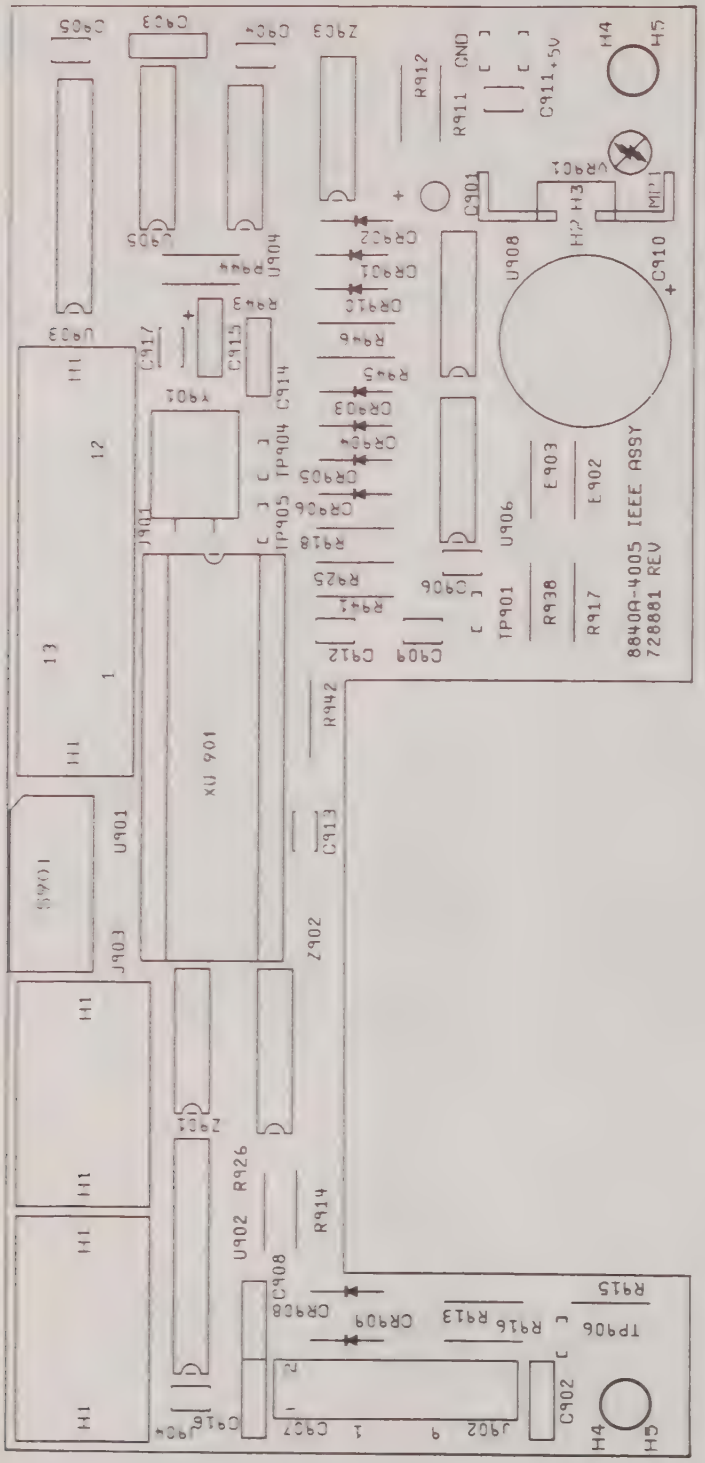
TABLE 805-1. IEEE-488 INTERFACE PCA
(SEE FIGURE 805-2.)

REFERENCE DESIGNATOR A->NUMERICS--->	S	----------DESCRIPTION----------	FLUKE STOCK --NO--	MFRS SPLY CODE-	MANUFACTURERS PART NUMBER --OR GENERIC TYPE--	TOT QTY	R S -Q	NOT -E
C 901		CAP,TA,1UF,+-20%,35V	697417	05571	199D	1		
C 902,903,907, 908		CAP,CER,0.01UF,+80-20%,50V,Z5V	697284 697284	71590	2DDH61	4		
C 904-906,911, 916,917		CAP,CER,0.22UF,+80-20%,50V,Z5U	649939 649939	71590	CZ20	6		
C 909		CAP,CER,430 PF,+-5%,50V	528489	71590	CN30	1		
C 910		CAP,AL,4700UF,+30-20%,16V	460261	54473	ECE-T16R4700S	1		
C 912-914		CAP,CER,1000PF,+-20%,50V,X7R	697458	71590	CW20	3		
C 915		CAP,TA,47UF,+-20%,10V	733246	56289	199D	1		
CR 901,902	*	ZENER,UNCOMP, 3.9V,10%, 20.0MA, 0.4W	698654	22767	1N748	2	1	
CR 903-906,910	*	DIODE,SI,BV= 75.0V,IO=150MA,500MW	698720	57668	1N4448	5	1	
CR 908,909	*	DIODE,SI, 100 PIV, 1.0 AMP	707067	57668	1N4002	2	1	
E 902		RES, CF, <0.02 OHMS	697060	09021	Z-25	1		
H 1		RIVET, .120 X .281	650283	12014	R3647X.281	6		
H 2		NUT, HEX, DOUBLE CHAMFER, 4-40	184044	73734	8002A-NP	1		
H 3		SCREW,MACHINE,PHP,STEEL,4-40X3/16	129882	73734	19022	1		
H 4		GROMMET LATCH	682898	83014	HN4G-44-5	2		
H 5		PLUNGER LATCH	682906	83014	HN4P-44-4-1	2		
H 6		JACK SCREWS	681940	89536	681940	2		
H 7		PAD, ADHESIVE	735365	89536	735365	1		
H 8		INSULATOR	508630	89536	508630	1		
J 901		CONN,PWB,RIBBON,90,24 POS,STD ORIENT	658039	02660	57-92245-12	1		
J 902		HEADER,VERTICAL L-LATCH W/KEYS 10POS	697359	28213	3446-6302	1		
J 903,904		CONN,COAX,BNC,REC,90,PWB	658542	00779	226978-1	2		
MP 1		HEATSINK	414128	13103	6030B-TT	1		
R 911,912		RES.CF,33K,+-5%,0.25W	573485	89536	573485	2		
R 913,914		RES,CF,1.5K,+-5%,0.25W	573212	80031	CR251-4-5P1K5	2		
R 915,916		RES,CF,470,+-5%,0.25W	573121	80031	CR251-4-5P470E	2		
R 917,918,938, 941,942		RES,CF,100,+-5%,0.25W	573014 573014	80031	CR251-4-5P100E	5		
R 925,926		RES,CF,3.3K,+-5%,0.25W	573287	80031	CR251-4-5P3K3	2		
R 943		RES,CF,68K,+-5%,0.25W	573550	80031	CR251-4-5P68K	1		
R 944		RES,CF,51K,+-5%,0.25W	573535	09021	CF1/4	1		
R 945,946		RES,CF,10K,+-5%,0.25W	573394	80031	CR251-4-5P10K	2		
S 901		SWITCH, DIP	658567	00779	7900	1		
TM 3		IEEE 488 QUICK REFERENCE GUIDE	729012	89536	729012	1		
TP 901-906		CONN,TAB,FASTON,PRESS-IN,0.110 WIDE	512889	02660	62395	6		
U 901	*	IC,NMOS,8 BIT MICROCMPUTR,8840A-90010	723122	56708	Z8611PS	1	1	
U 902,903	*	IC,LSTTL,OCTL IEEE-488 BUS TRANSCVR	524835	04713	MC3447P	2	2	
U 904	*	IC,LSTTL,QUAD 2 INPUT NAND GATE	394205	01295	SN74LS03N	1	1	
U 905	*	IC,LSTTL,HEX INVERTER W/3-STATE OUT	654442	01295	SN74LS368AN	1	1	
U 906	*	IC,LSTTL,QUAD 2 IN NAND W/SCHMT TRIG	504449	01295	SN74LS132N	1	1	
U 908	*	IC,COMPARATOR,QUAD,14 PIN DIP	387233	12040	LM339N	1	1	
VR 901	*	IC,VOLT REG,FIXED,+5 VOLTS,1.5 AMPS	428847	04713	MC7805CT	1	1	
XU 901		SOCKET,DIP,0.100 CTR,40 PIN	756668	89536	756668	1		
Y 901	*	CRYSTAL,8.00MHZ QUARTZ HC-18U	707133	89536	707133	1	1	
Z 901		RES,NET,DIP,14 PIN,13 RES,10K,+-5%	355313	01121	314	1		
Z 902		RES,NET,DIP,16 PIN,8 RES,3.3K,+-5%	572073	01121	314	1		
Z 903		RES,NET,DIP,14 PIN,13 RES,3.3K,+1- 5%	733402	01121	314	1		

CAUTION

*

DEVICES INDICATED BY THE ABOVE SYMBOL ARE SUBJECT TO DAMAGE BY STATIC DISCHARGE.



8840A-1605

Figure 805-2. IEEE-488 Interface, Option -05

Option -09
True AC RMS AC

809-1. INTRODUCTION

The True RMS AC option gives the 8840A the ability to make ac voltage and current measurements. The ac functions are selected with the front panel VAC and mA AC buttons, or by remote commands if the IEEE-488 Interface option is installed. Specifications for Option -09 are shown in Section 1, Table 1-1.

809-2. INSTALLATION

The True RMS AC option is contained on a single, easy-to-install printed circuited assembly (PCA). To install the option, proceed as follows:

WARNING

TO AVOID ELECTRIC SHOCK, DISCONNECT THE POWER CORD AND TEST LEADS BEFORE REMOVING THE INSTRUMENT CASE.

1. Remove the grounding screw from the bottom of the case and remove the two rear panel mounting screws (Figure 809-1A).

2. Holding the front panel, slide the case and rear bezel off of the chassis (Figure 809-1B). (At this point, the rear bezel is not secured to the case.)

3. Holding the True RMS AC PCA slightly above the chassis, component side down, connect the the ribbon cable from the True RMS AC PCA to the Main PCA and latch it in place. (See Figure 809-1C and D.)

4. Connect the red lead from the True RMS AC PCA to stud J301 on the Main PCA. (See Figure 809-1C.) The stud is located next to the forward end of the FRONT/REAR switch.

5. Make sure the heads of the four plastic latches are in the extended position. Guide the PCA into the 4 circuit board supports.

6. Fasten the True RMS AC PCA to the chassis by pressing the four nylon latches into the mounting supports on the chassis. (See Figure 809-1E.)

7. Reinstall the cover and rear bezel on the chassis and attach the two rear panel mounting screws.

8. Attach the grounding screw to the bottom of the case.

WARNING

TO AVOID ELECTRIC SHOCK, ENSURE THE GROUNDING SCREW IS FIRMLY ATTACHED TO THE CASE BOTTOM.

9. Calibrate the VAC voltage and mA AC functions according to the calibration instructions given in the Maintenance section.

809-3. OPERATING INSTRUCTIONS

For operating instructions, refer to Section 2. For ac measurement considerations, refer to Section 4.

809-4. MAINTENANCE

All service information regarding Option -09 is contained in Section 6. The theory of operation is contained in Section 5.

809-5. LIST OF REPLACEABLE PARTS

A list of replaceable parts for the True RMS AC printed circuit assembly (PCA) is given in Table 809-1. Refer to Section 7 for ordering information.

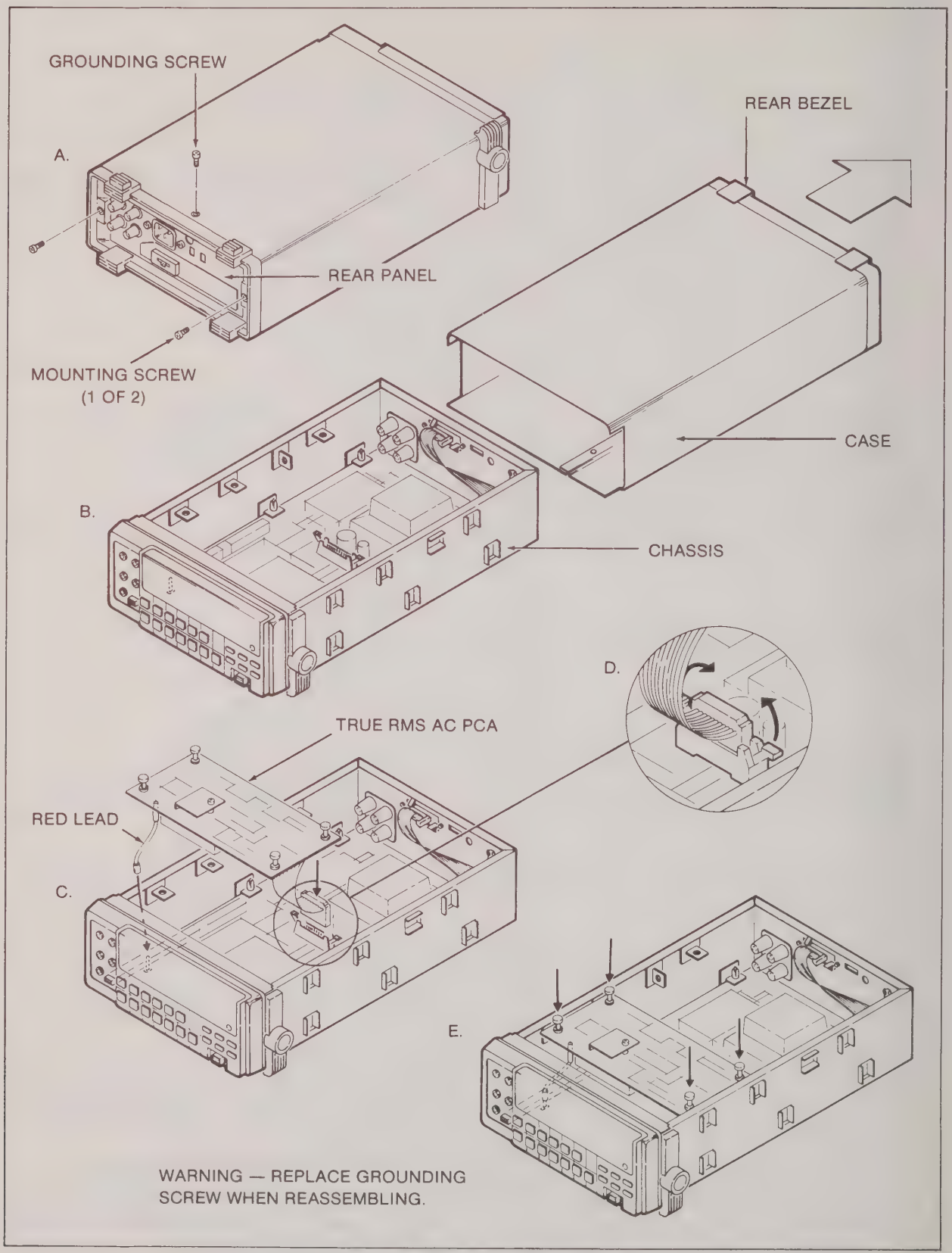


Figure 809-1. Installing Option -09

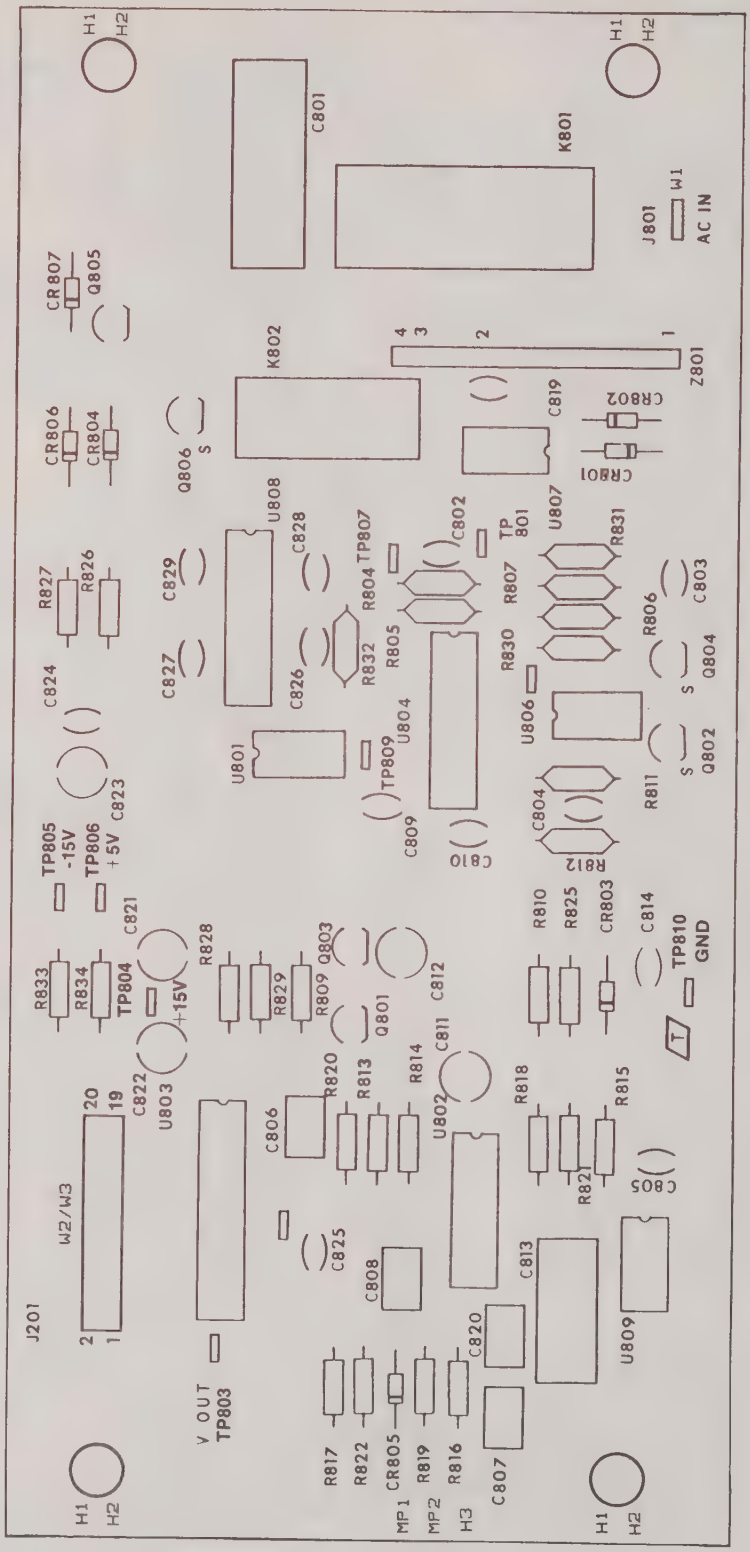
TABLE 809-1. TRUE RMS AC PCA
(SEE FIGURE 809-2.)

REFERENCE DESIGNATOR A->NUMERICS---)	S	----------DESCRIPTION----------	FLUKE STOCK --NO--	MFRS SPLY CODE-	MANUFACTURERS PART NUMBER --OR GENERIC TYPE---	TOT QTY	R S -Q	NOT -E
C 801		CAP,POLYES,0.068UF,+-10%,1000V	714816	60935	160	1		
C 802		CAP, CER, 56PF, +-2%, 50V, COG	714378	71590	CN20	1		
C 803		CAP,CER,33PF,+-2%,50V,COG	715292	71590	CN20	1		
C 804		CAP,CER,6.8PF,+-0.25PF,50V,M7J	715243	51406	RPE122	1		
C 805		CAP,CER,470PF,+-10%,50V,COG	733071	71590	CN20	1		
C 806-808,820		CAP,POLYES,0.47UF,+-10%,50V	697409	60935	185	4		
C 809,810,824		CAP,CER,0.22UF,+80-20%,50V,Z5U	649939	71590	CZ20	3		
C 811,812		CAP,TA,1UF,+-20%,35V	697417	05571	199D	2		
C 813		CAP,POLYES,1.0UF,+-10%,50V	733089	89536	733089	1		
C 814		CAP,CER,1000PF,+-20%,50V,X7R	697458	71590	CW20	1		
C 819		CAP,CER,1.2PF,+-0.25PF,50V,M7J	715235	51406	RPE122	1		
C 821		CAP,TA,10UF,+-20%,10V	714766	56289	199D	1		
C 822,823		CAP,TA,10UF,+-20%,25V	714774	56289	199D	2		
C 825		CAP,CER,0.01UF,+80-20%,50V,Z5V	697284	71590	2DDH61	1		
C 826		CAP,CER,39PF,+-2%,50V,COG	714840	71590	CN20	1		
C 827		CAP,CER,12PF,+-2%,100V,COG	715169	71590	CN20	1		
C 828		CAP,CER,68PF,+-2%,50V,COG	715300	71590	CN20	1		
C 829		CAP,CER,22PF,+-2%,50V,COG	714832	71590	CN20	1		
CR 801,802	*	DIODE,SI,BV= 20.0V,IO= 50MA,250 MW	698738	07263	FD700	2	1	
CR 803-805	*	DIODE,SI,BV= 75.0V,IO=150MA,500MW	698720	57668	1N4448	3	1	
H 1		GROMMET, LATCH	682898	83014	HN4G-44-5	4		
H 2		PLUNGER, LATCH	682906	83014	HN4P-44-4-1	4		
H 3		SCREW,MACHINE,PHP,STEEL,6-32X1/2	152173	89536	152173	1		
K 801		RELAY,REED,1 FORM A,5V,HIGH VOLTAGE	714352	71707	3400-0087	1	1	
K 802		RELAY,REED,1 FORM A,4.5VDC	404590	71707	CR4503	1	1	
MP 1		SHIELD, AC BOTTOM	656421	89536	656421	1		
MP 2		SHIELD, AC	745471	89536	745471	1		
Q 801,803,805	*	TRANSISTOR,SI,PNP,T092	698233	07263	2N3906	3	1	
Q 802,804,806	*	TRANSISTOR,SI,N-JFET,REMOTE CUTOFF	707968	89536	707968	3	1	
R 804,805,830,		RES,MF,10K,+-1%,0.125W,50PPM	706937	09021	MF	4		
R 831			706937					
R 806,811		RES,MF,20K,+-0.1%,0.125W,25PPM	706168	09021	MF	2		
R 807		RES,MF,5K,+-0.1%,0.125W,25PPM	706135	09021	MF	1		
R 809		RES,CF,8.2K,+-5%,0.25W	573378	80031	CR251-4-5P8K2	1		
R 810,820,825-		RES,CF,100K,+-5%,0.25W	573584	80031	CR251-4-5P100K	5		
R 827			573584					
R 812		RES,MF,2.222K,+-0.1%,0.125W,25PPM	706143	09021	MF	1		
R 813		RES,CF,330K,+-5%,0.25W	641159	80031	CR251-4-5P330K	1		
R 814		RES,CF,20,+-5%,0.25W	572958	80031	CR251-4-5P20E	1		
R 815,818,829		RES,CF,15K,+-5%,0.25W	573428	80031	CR251-4-5P15K	3		
R 816,819		RES,CF,75K,+-5%,0.25W	641134	09021	CF1/4	2		
R 817		RES,CF,91K,+-5%,0.25W	573576	09021	CF1/4	1		
R 821		RES,CF,7.5K,+-5%,0.25W	573360	09021	CF1/4	1		
R 822		RES,CF,2K,+-5%,0.25W	573238	80031	CR251-4-5P2K	1		
R 828		RES,CF,12K,+-5%,0.25W	573402	80031	CR251-4-5P12K	1		
R 832		RES, MF,4.99K 1%, 1/8W 500PPM	714923	09021	MF	1		
R 833,834		RES,CF,10,+-5%,0.25W	572941	80031	CR251-4-5P10E	2		
TP 801-811		TEST POINTS	512889	89536	512889	11		
U 801,806	*	IC OP AMP,DUAL,HIGH SPEED	707976	18324	NE5532N	2	1	
U 802	*	IC,BPLR,TRUE RMS TO DC CONVERTER	707653	24355	AD637	1		
U 803	*	IC,TTL,OCTAL D F/F,+EDG TRG	473223	01295	SN74LS374N	1	1	
U 804,808	*	IC,CMOS,QUAD BILATERAL SWITCH	586735	17856	DG211CJ	2	1	
U 807	*	IC,OP AMP,JFET INPUT,8 PIN DIP	472779	12040	LF356N	1	1	
U 809	*	IC,OP AMP,DUAL,JFET INPUT,8 PIN DIP	495192	12040	LF353BN	1		
W 1		WIRE ASSY, AC CONNECT	684316	89536	684316	1		
W 3		CABLE ASSY,20 COND.FLAT,4.5L IDC/DRB	714014	30146	1003018-A	1		
Z 801	*	RESISTOR NETWORK AC INPUT DIVIDER	704478	89536	704478	1	1	

CAUTION

*

DEVICES INDICATED BY THE ABOVE SYMBOL ARE SUBJECT TO DAMAGE BY STATIC DISCHARGE.



8840A-1609

Figure 809-2. True RMS AC Converter, Option -09

Section 9
Manual Change Information

9-1. INTRODUCTION

Table 9-1 contains information necessary to backdate this manual to conform with earlier printed circuit assembly (PCA) configurations.

As changes and improvements are made to the instrument, they are identified by incrementing the revision letter marked on the affected PCA. These changes are documented on a supplemental change/errata sheet which, when applicable, is inserted at the front of the manual. To identify the configuration of the PCAs used in your instrument, refer to the revision letter on the component side of each PCA.

9-2. BACKDATING INSTRUCTIONS

To backdate this manual to conform with an earlier assembly revision level, perform the changes indicated in Table 9-1. If this manual documents all PCAs at their original level, no changes are necessary, and no changes will be indicated in Table 9-1.

Table 9-1. Manual Status and Backdating Information

Ref Or Option No.	Assembly Name	Fluke Part No.	* To adapt manual to earlier rev configurations perform changes in desending order (by no.), ending with change under desired rev letter																						
			–	A	B	C	D	E	F	G	H	J	K	L	M	N	P									
	Main PCA	728857	●	●	●	●	X																			
05	IEEE PCA	728881	●	●	●	X																				
09	AC Converter TRMS PCA	728899	●	●	●	●	●	X																		

* X = The PCB revision levels documented in this manual.
● = These revision letters were never used in the instrument.
–= No revision letter on the PCB.

Section 10
Schematic Diagrams

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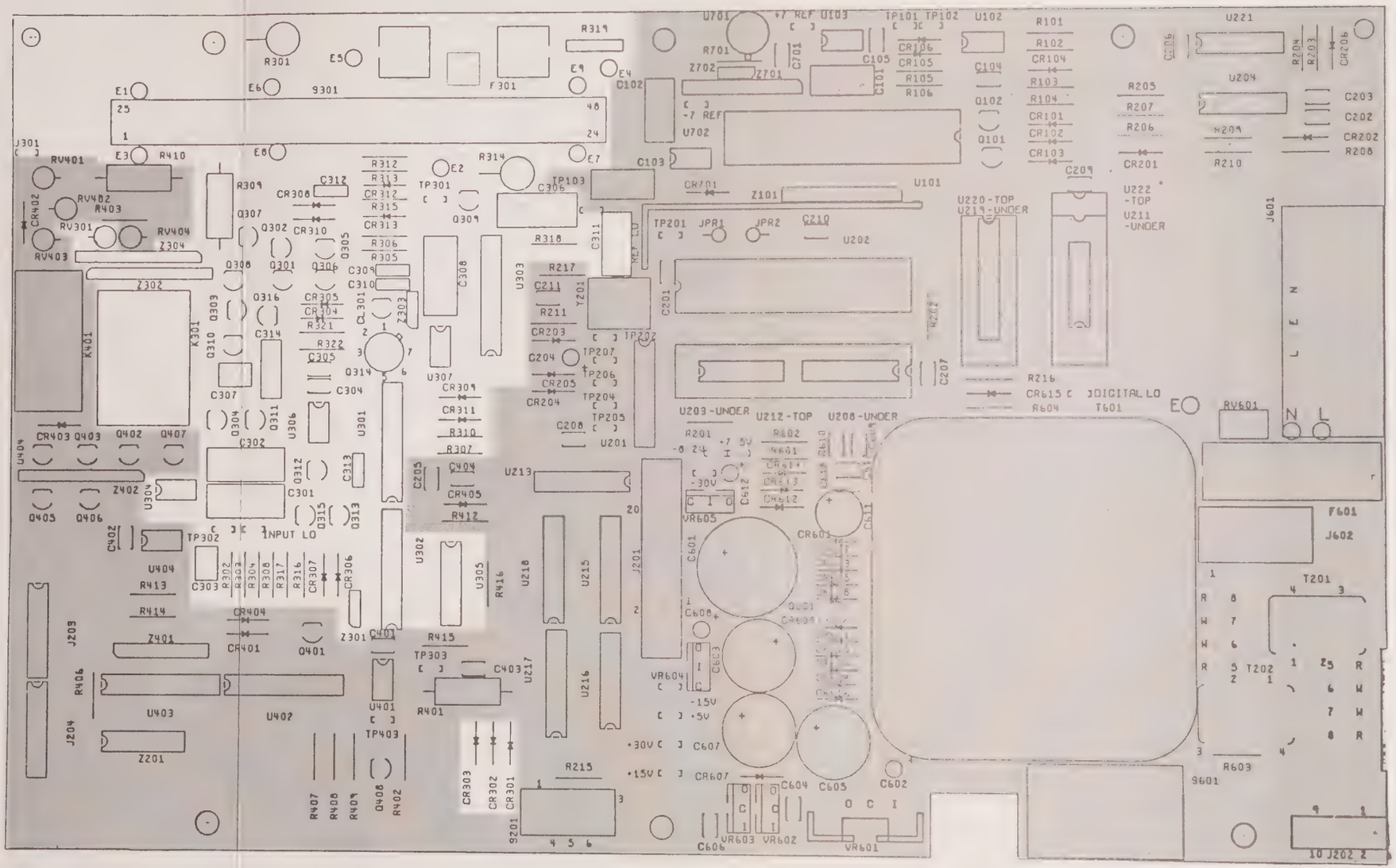


Figure 10-1. Main PCA, DC Scaling and F/R Switch

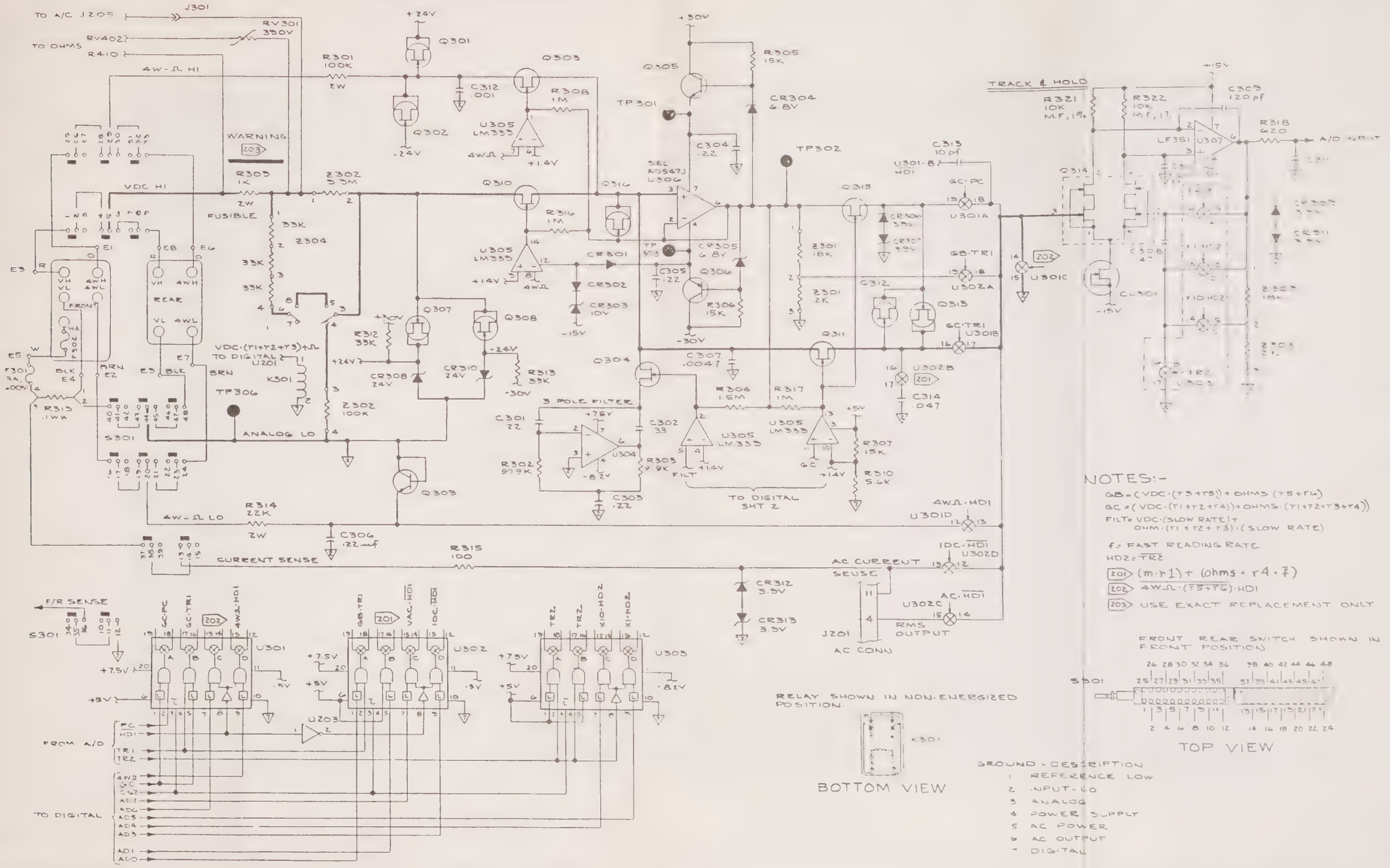


Figure 10-1. Main PCA, DC Scaling and F/R Switch (cont)

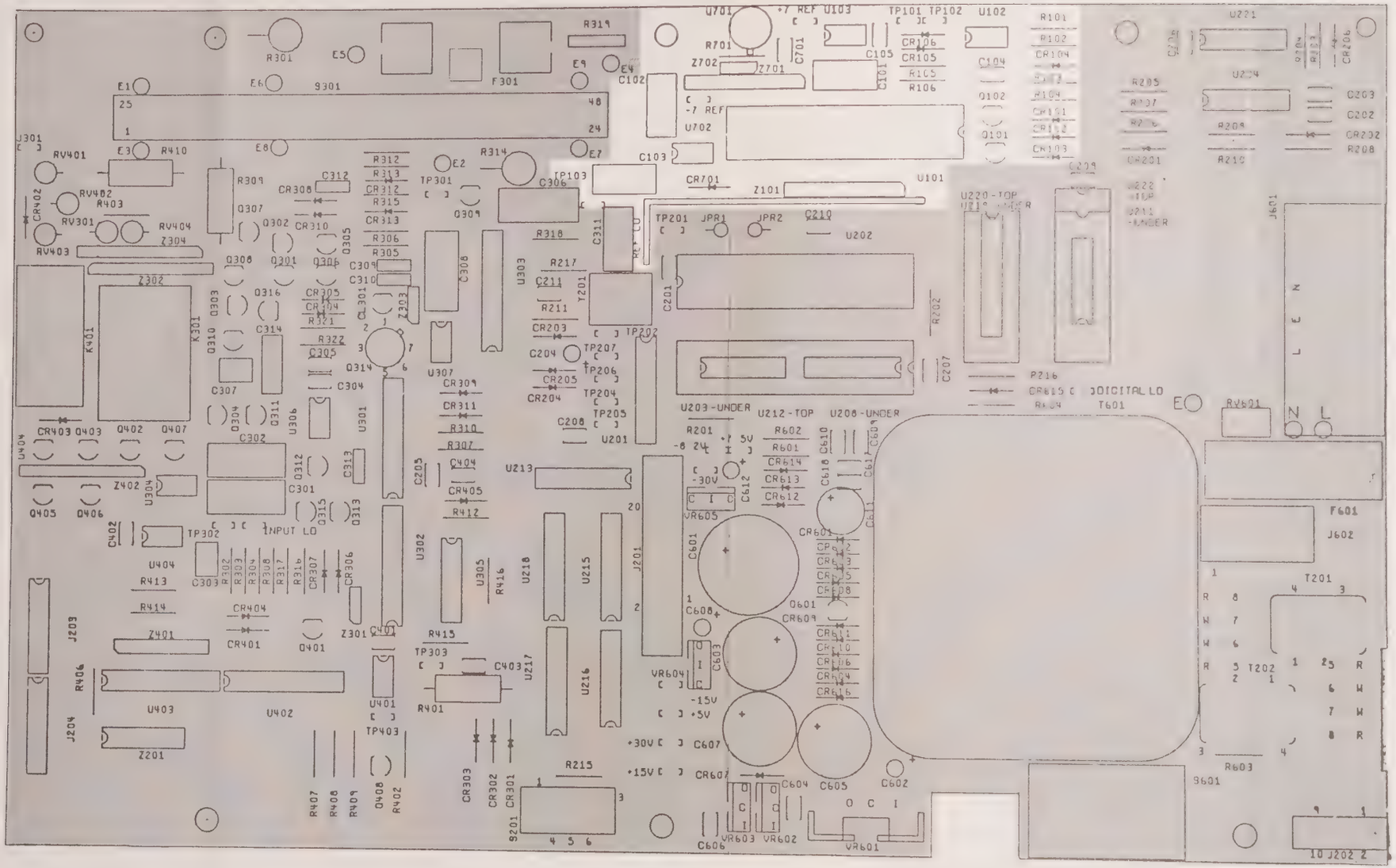
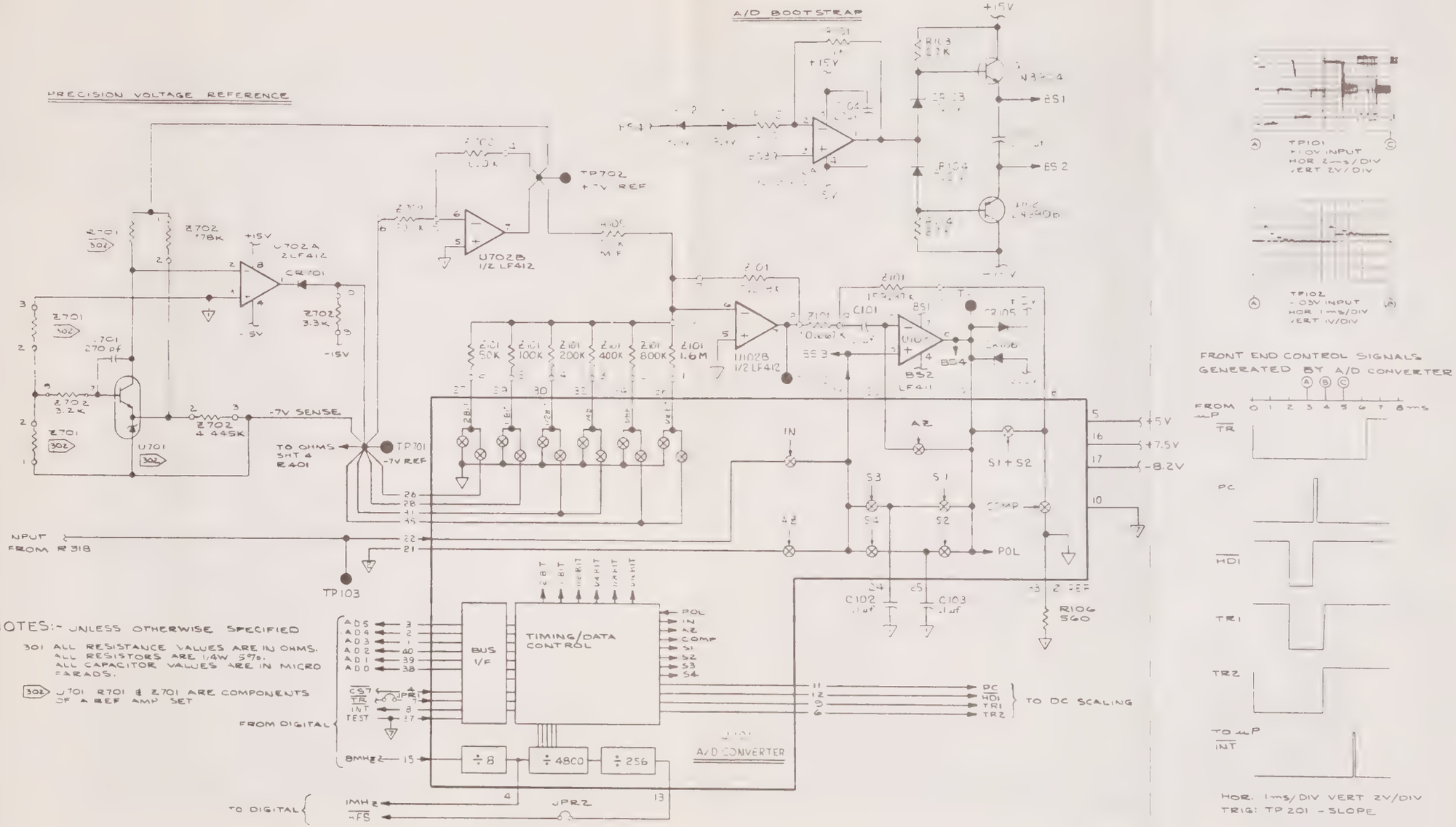
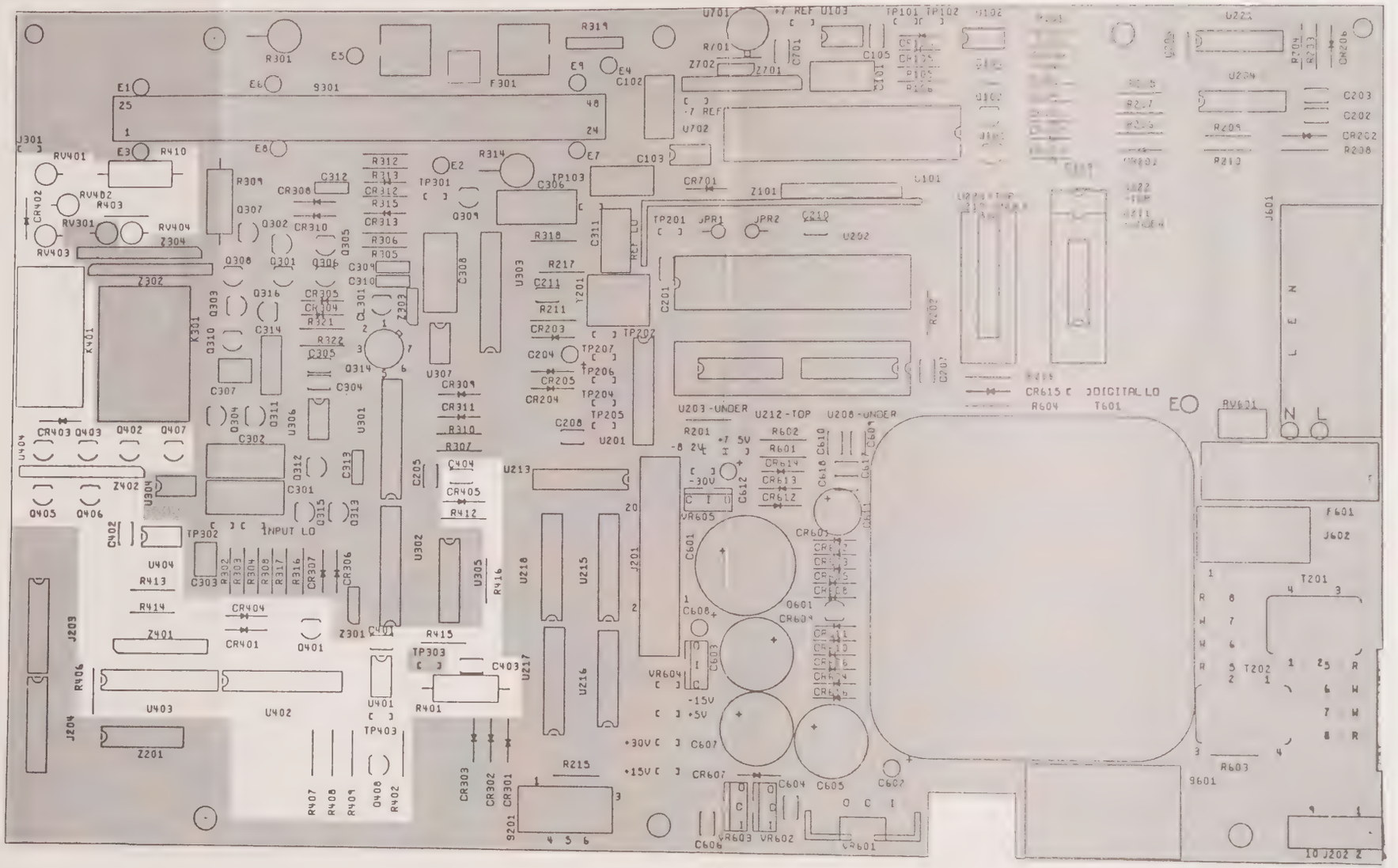


Figure 10-2. Main PCA, A/D Converter



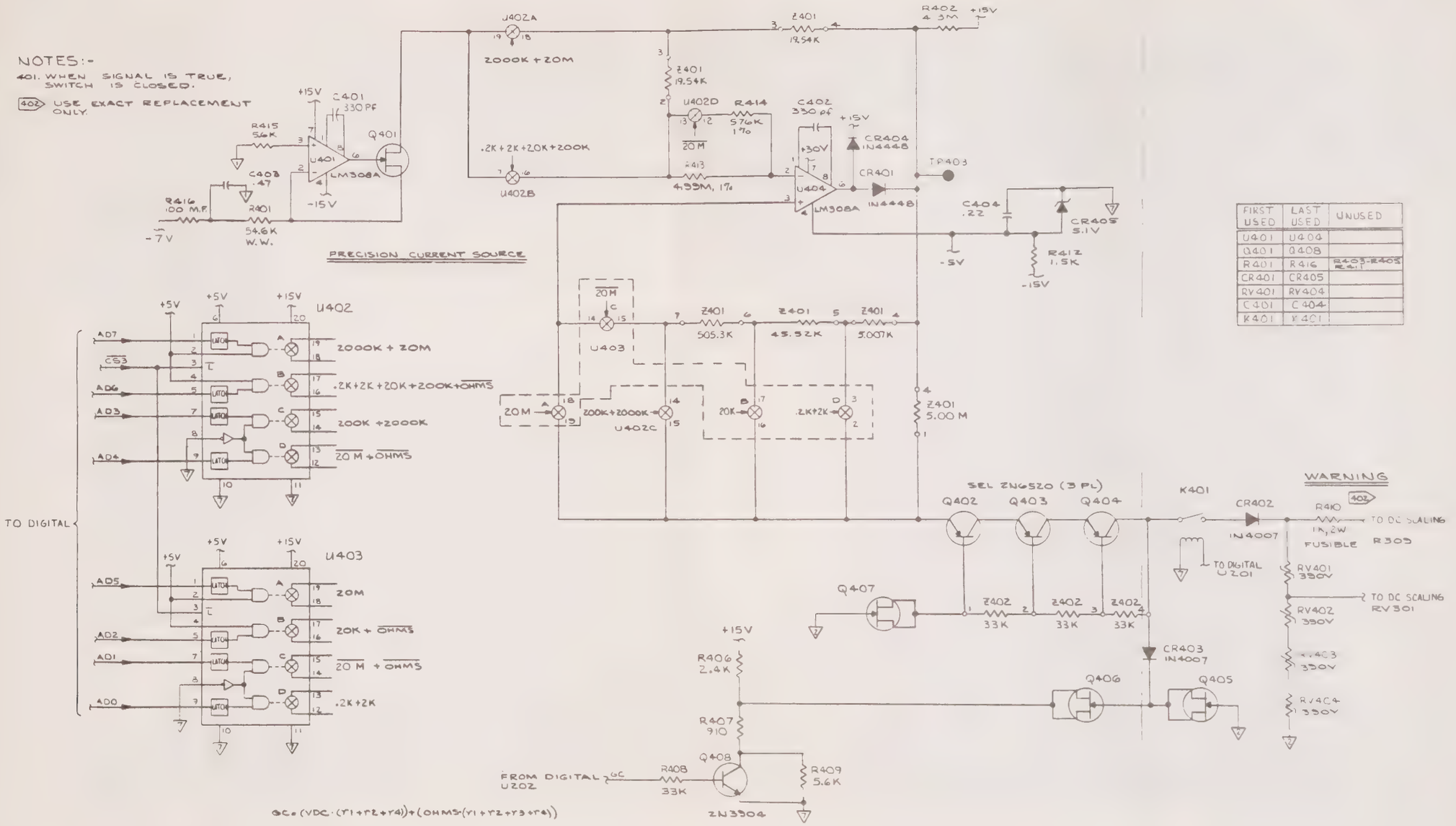
8840A-1001
(Sheet 2)

Figure 10-2. Main PCA, A/D Converter (cont)



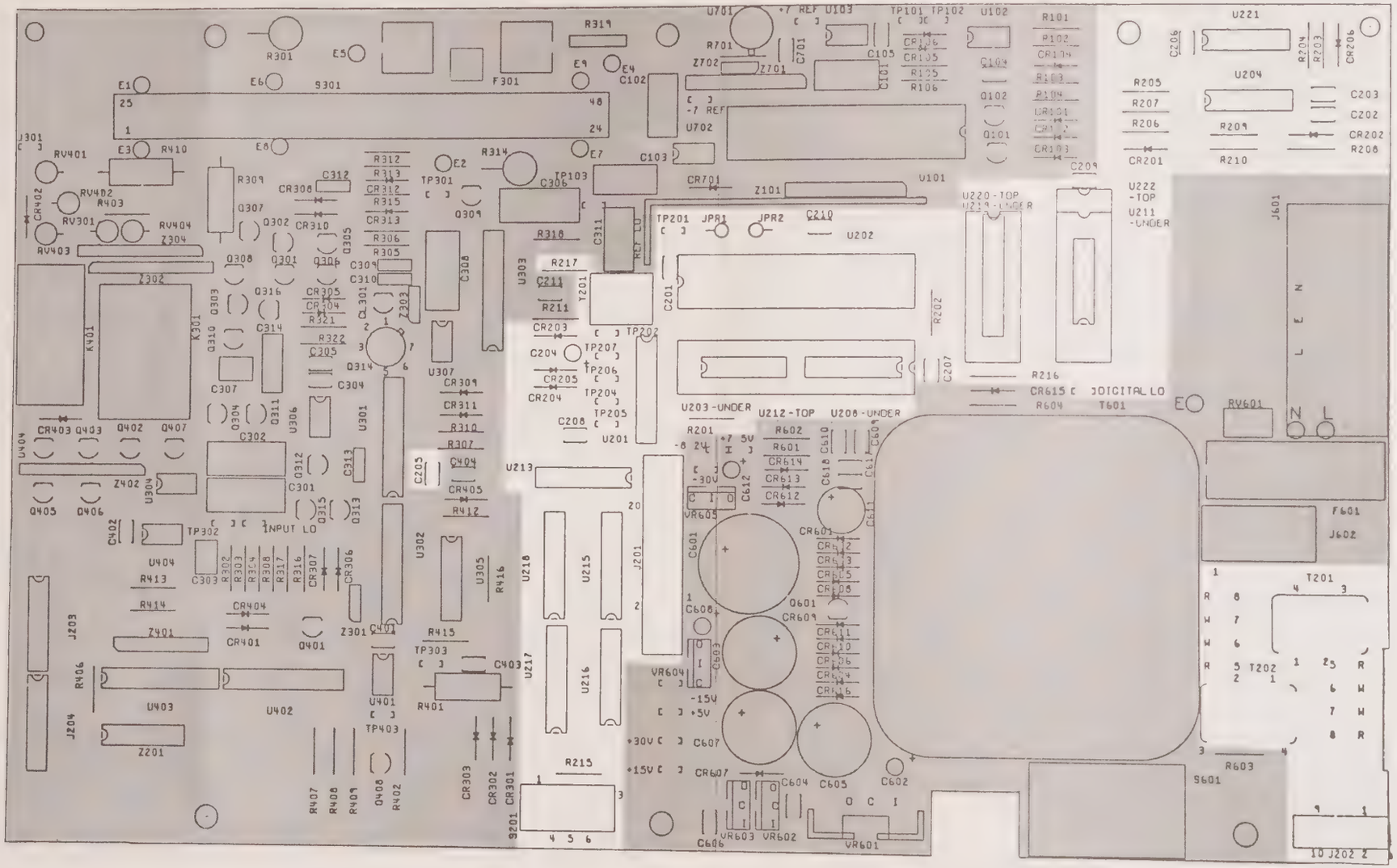
8840A-1601

Figure 10-3. Main PCA, Ohms Current Source



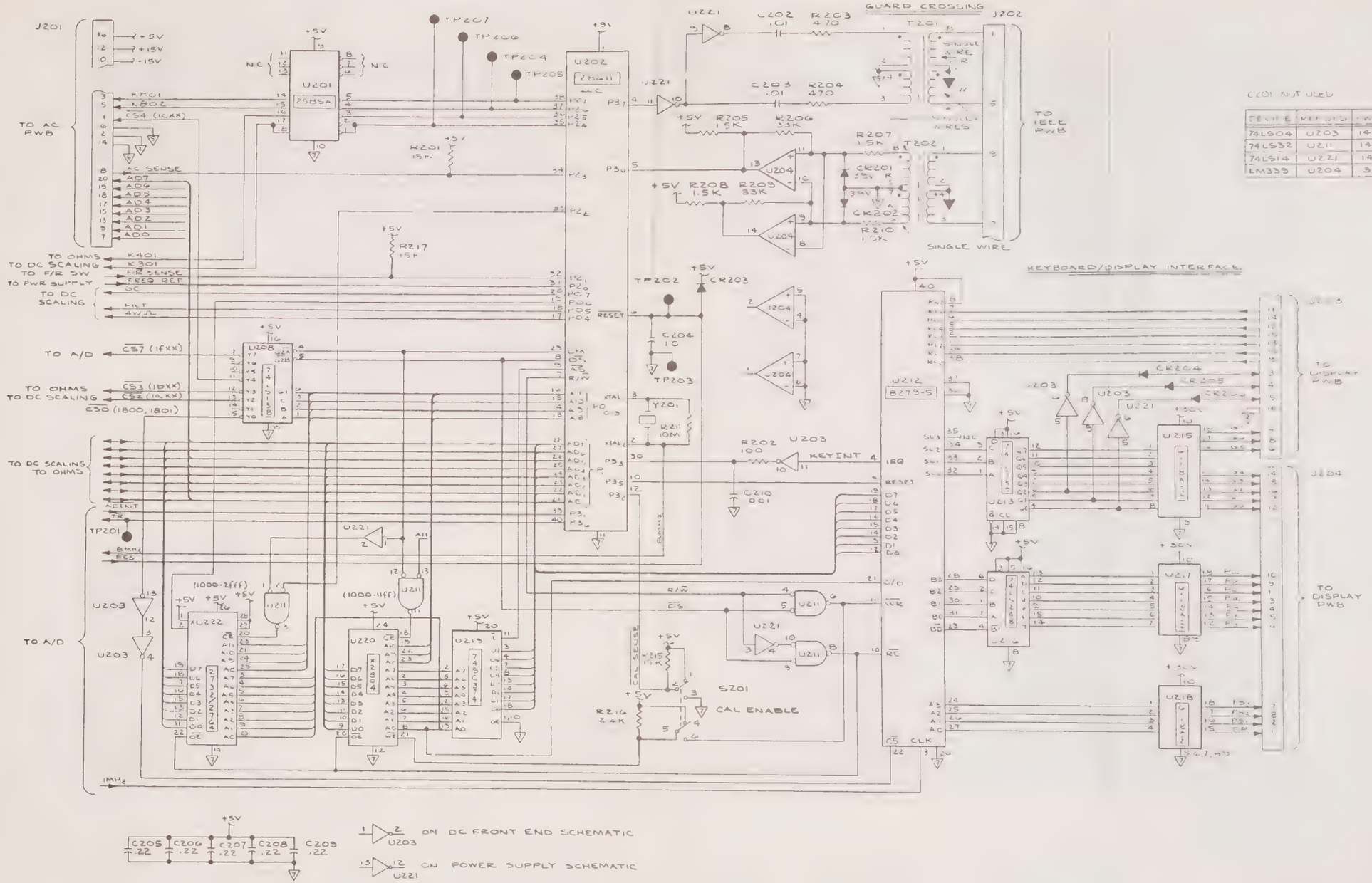
8840A-1001
(Sheet 3)

Figure 10-3. Main PCA, Ohms Current Source (cont)



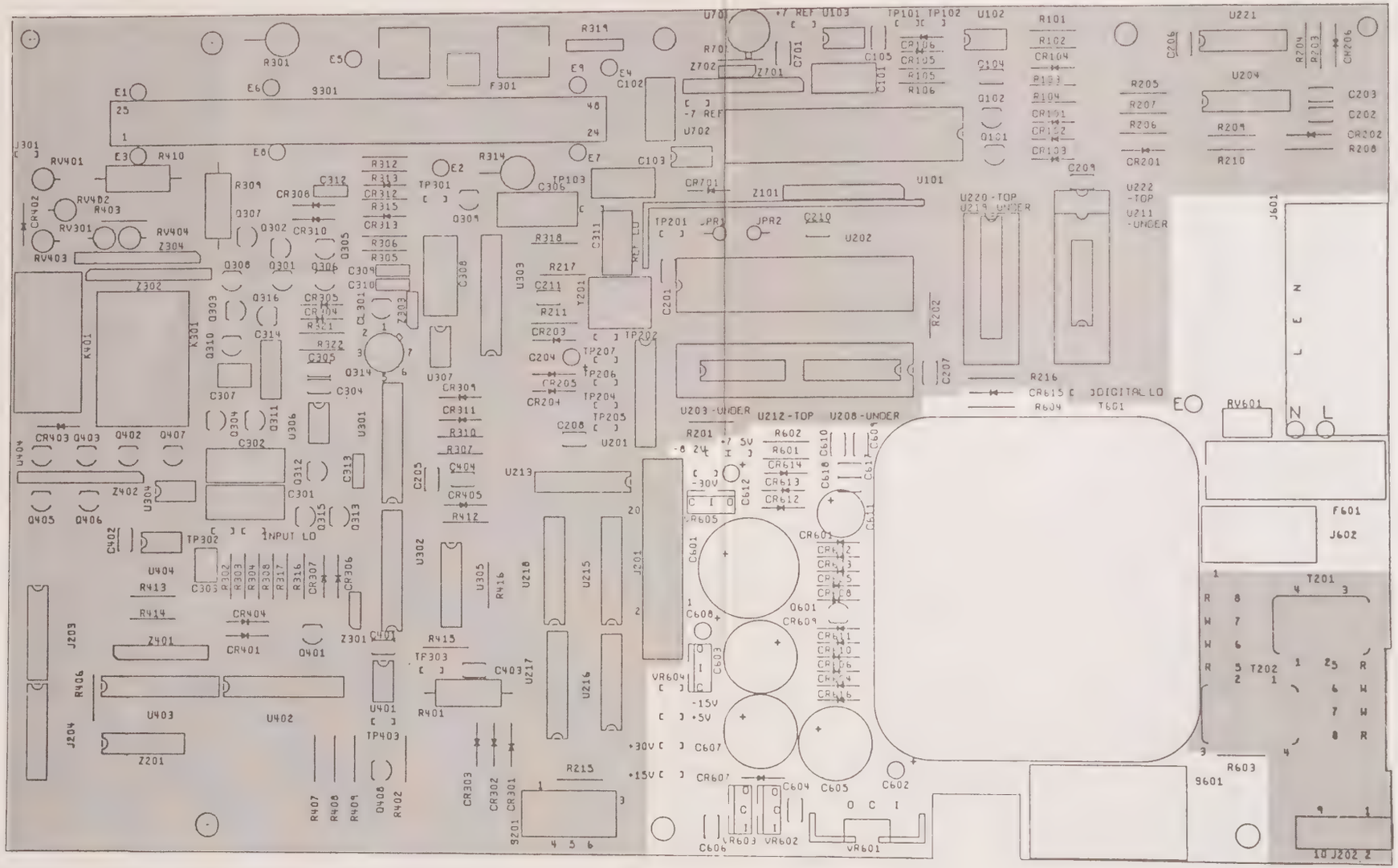
8840A-1601

Figure 10-4. Main PCA, Digital



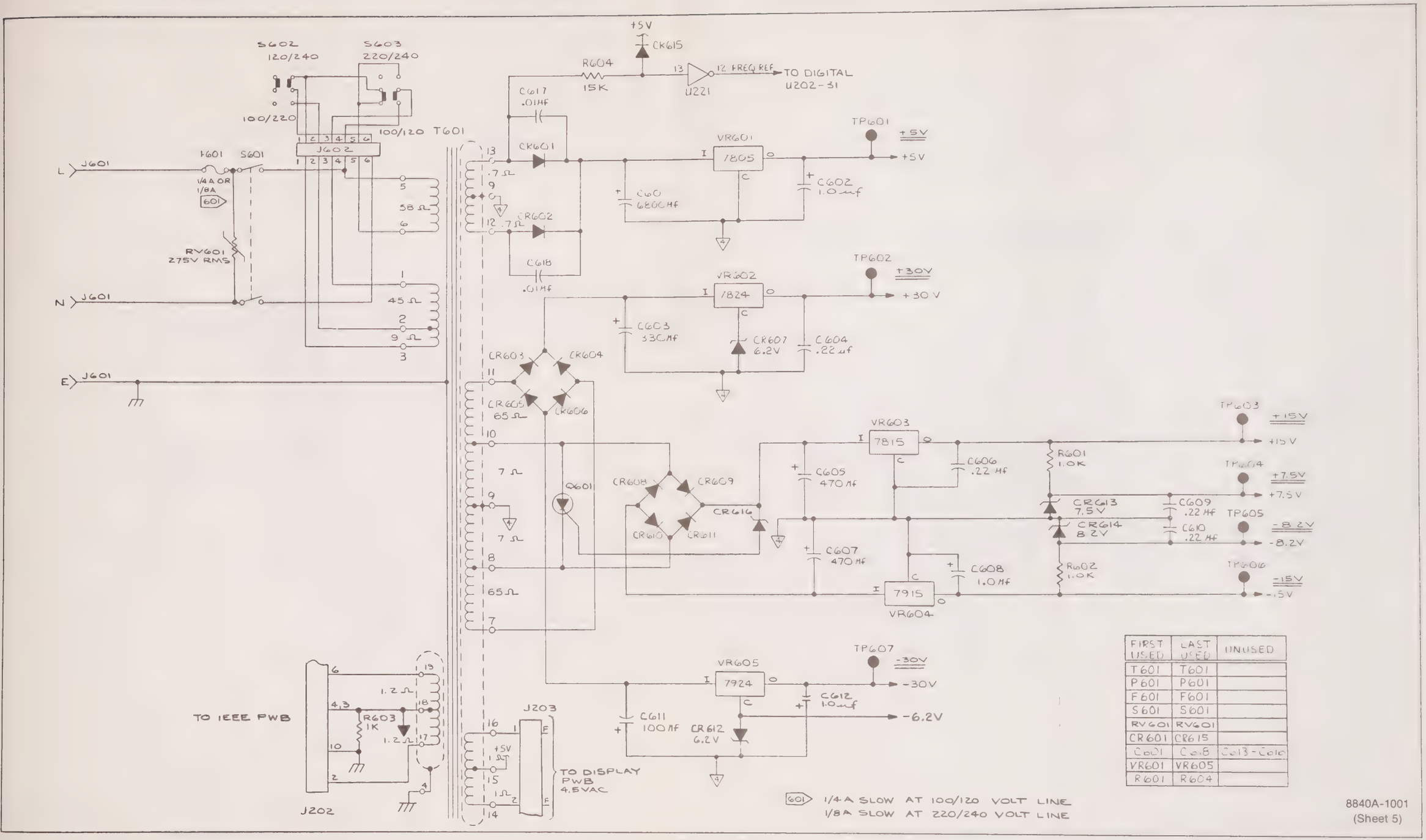
8840A-1001
(Sheet 4)

Figure 10-4. Main PCA, Digital (cont)



8840A-1601

Figure 10-5. Main PCA, Power Supply



FIRST USED	LAST USED	UNUSED
T601	T601	
P601	P601	
F601	F601	
S601	S601	
RV601	RV601	
CR601	CR615	
C601	C618	C613-C616
VR601	VR605	
R601	R604	

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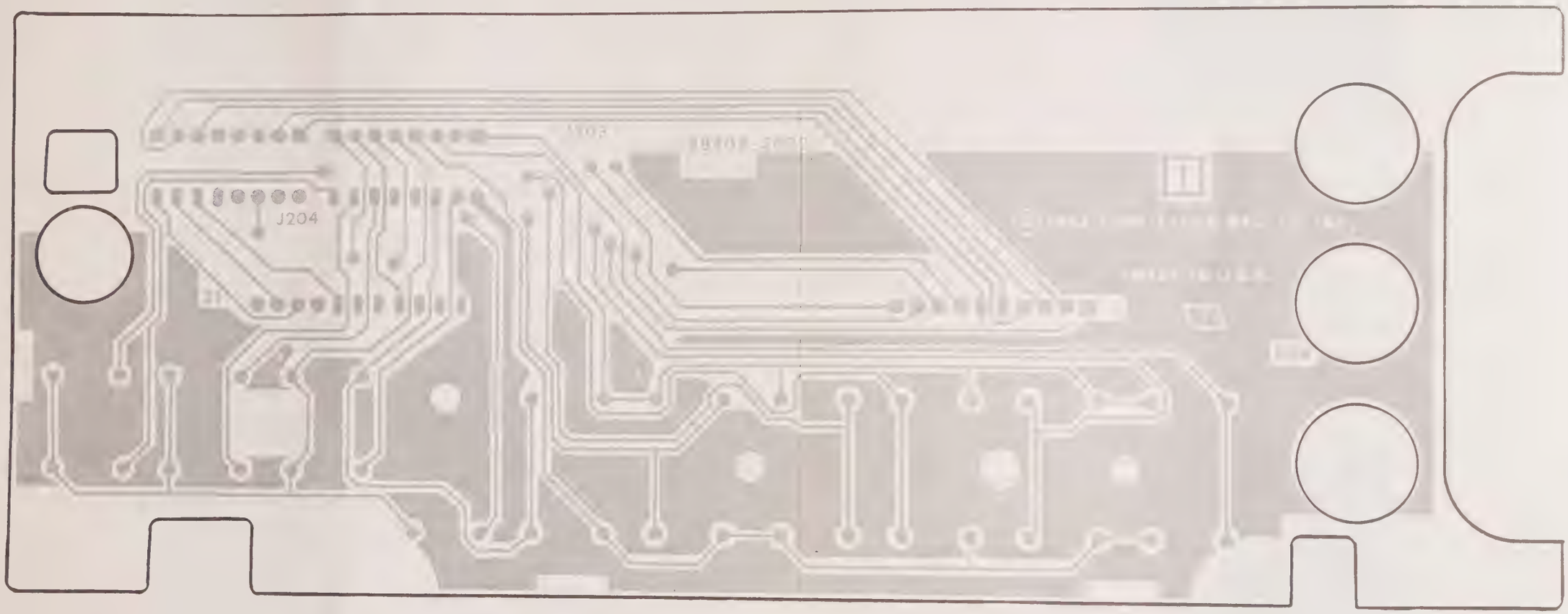
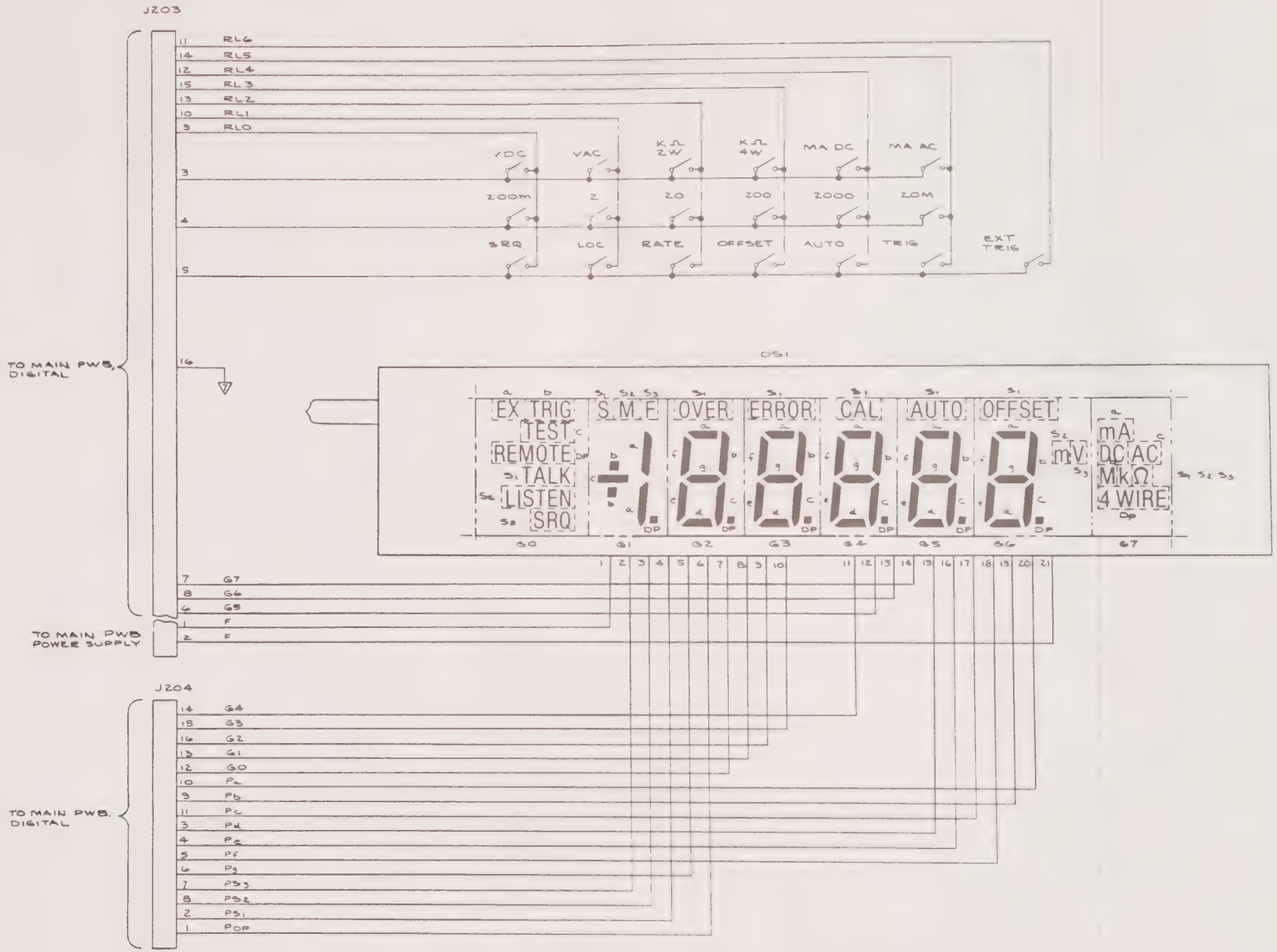
(Sheet 5)

Figure 10-5. Main PCA, Power Supply (cont)



8840A-1602

Figure 10-6. Display PCA



8840A-1002

Figure 10-6. Display PCA (cont)

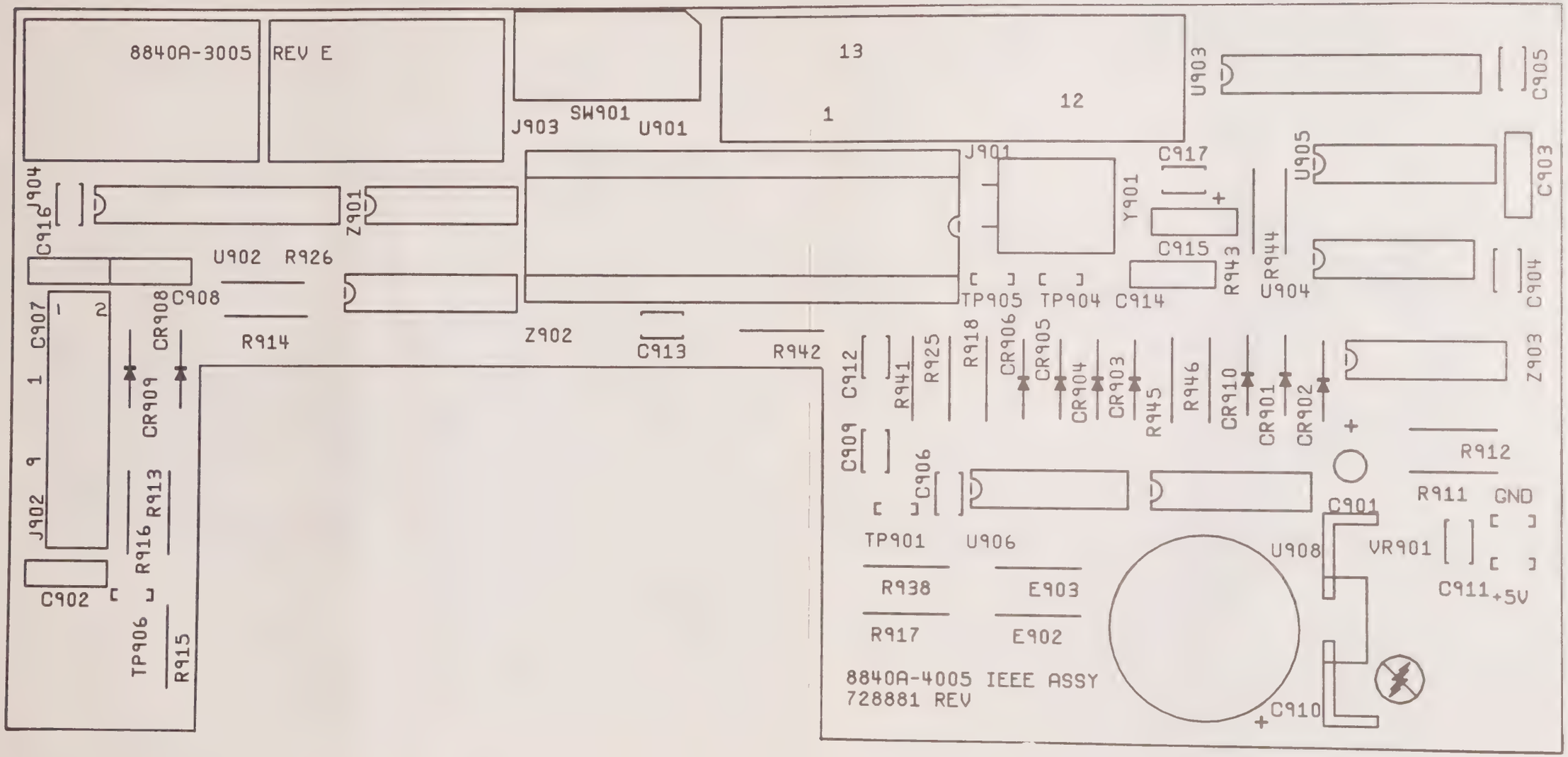
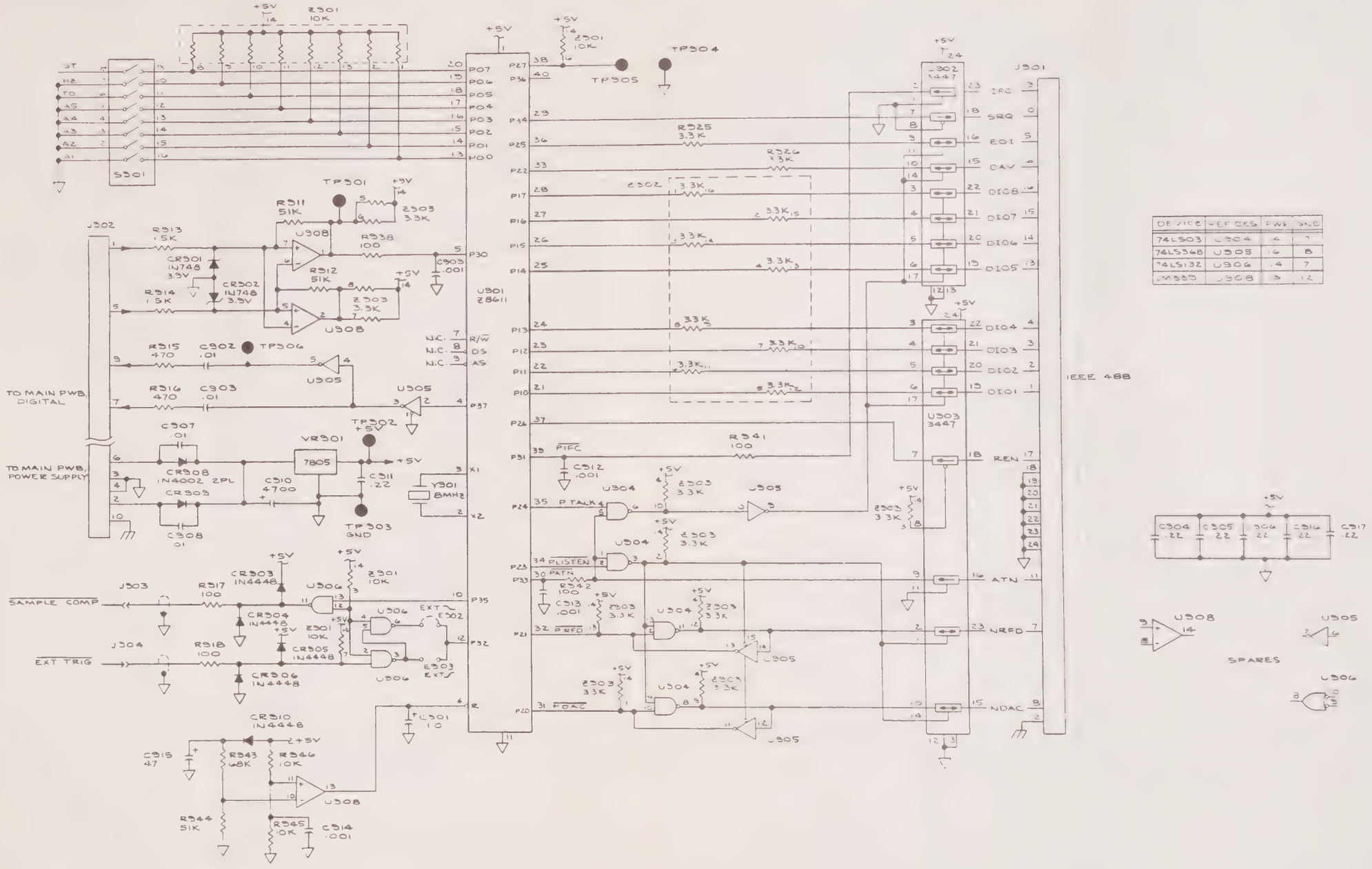
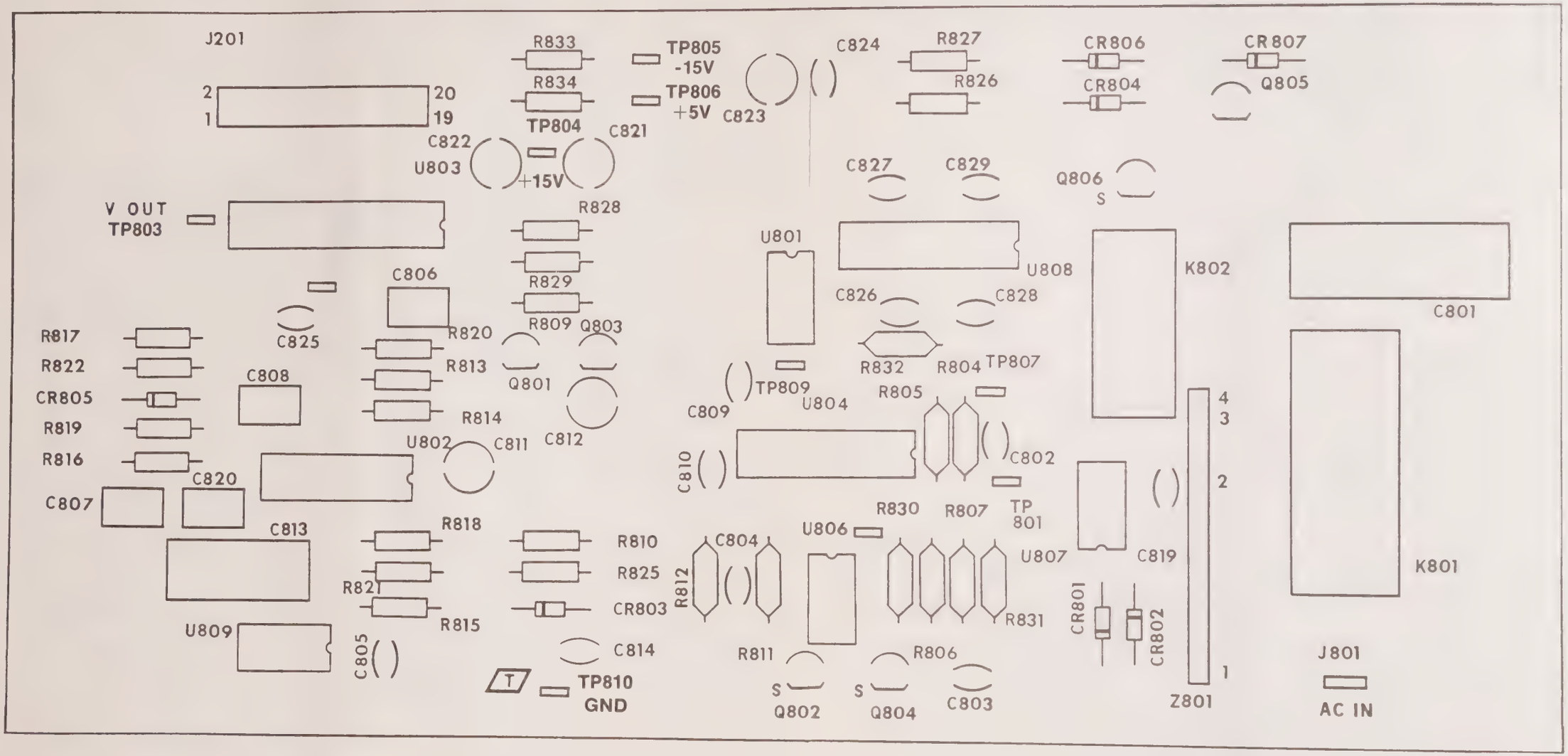


Figure 10-7. IEEE-488 Interface PCA, Option -05



DEVICE	REFERENCES	PWR	GND
74LS03	U904	4	7
74LS368	U905	16	8
74LS132	U906	14	7
MB89	U908	8	12

Figure 10-7. IEEE-488 Interface PCA, Option -05 (cont)



8840A-1609

Figure 10-8. True RMS AC PCA, Option -09

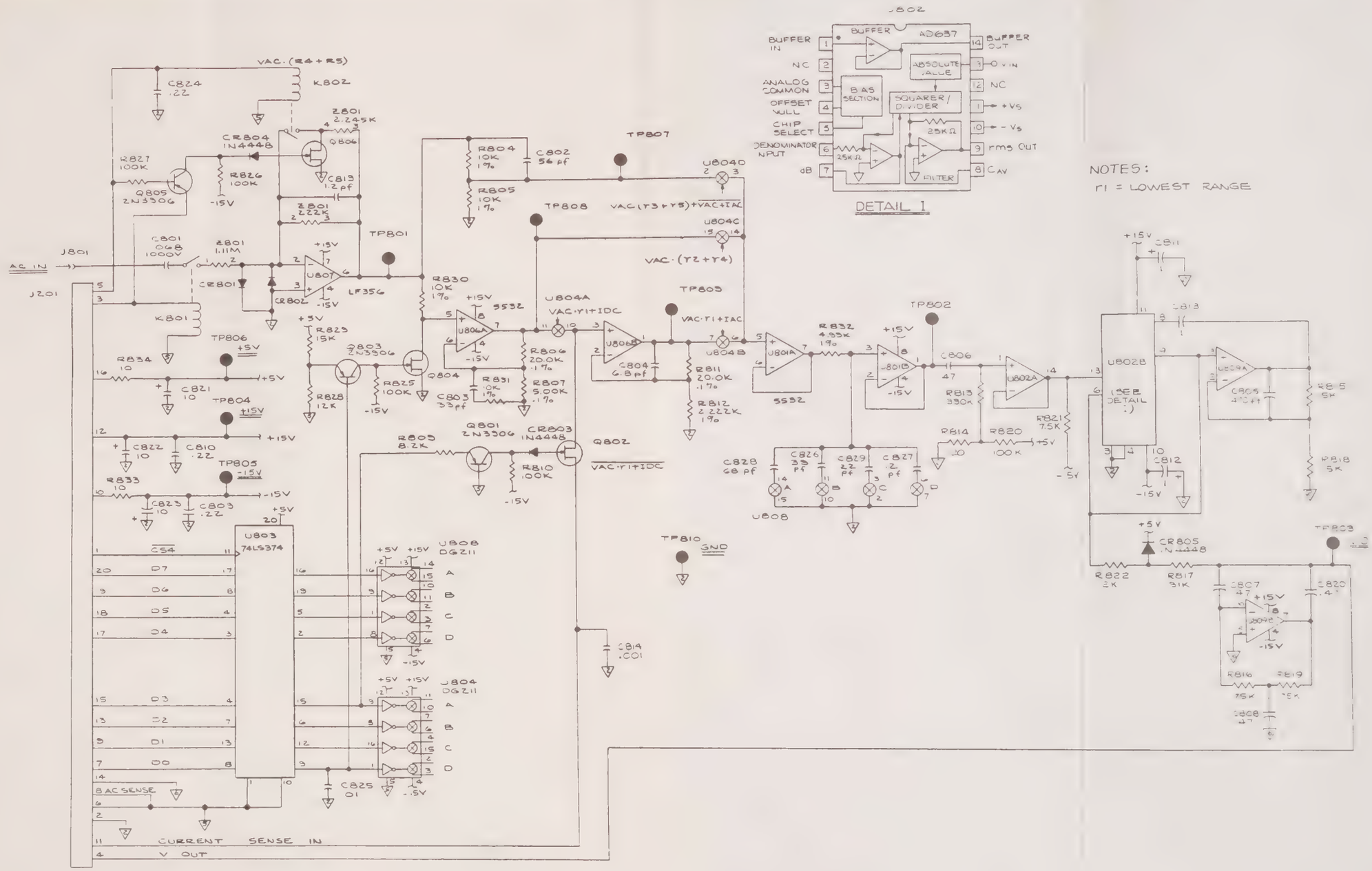


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Figure 10-8. True RMS AC PCA, Option -09 (cont)

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